EONTOLOGY LIBRARY

Volume 14 MARCH, 1940 Number 2

MAR 11 1940

Museum Library

# JOURNAL OF PALEONTOLOGY

*A Publication of*

The Society of Economic Paleontologists and Mineralogists

*A Division of the American Association of Petroleum Geologists*

*and*

The Paleontological Society

*An Associate of the Geological Society of America*

## CONTENTS

A new cystoid from the Ordovician of Oklahoma .*E. B. Branson and Raymond E. Peck* 89

Foraminifera from the Grayson formation of Northern Texas .....*Helen Tappan* 93

Radiolarian fauna of the Caballos formation, Marathon Basin, Texas .*Esther Aberdeen* 127

*Helicoprion* in the Permian of Western Australia .....*Curt Teichert* 140

The Gastropod Genus *Euphemites* in the Pennsylvanian of Texas .....*Ralph H. King* 150

PALEONTOLOGICAL NOTES

Check list of Mississippian Ostracoda of North America .....*I. G. Sohn* 154

*Aturia* in the Upper Miocene of Java .....*J. Wyatt Durham* 160

An occurrence of *Isotelus Gigas* Dekay in the Arbuckle Mountains, Oklahoma .....
.....*Alfred R. Loeblich, Jr.* 161

Megascopic fossils from the Permian reef trend of West Texas and New Mexico .....
.....*John M. Hills* 162

New names for Weches Ostracoda .....*A. H. Sutton and John R. Williams* 163

California Cretaceous Mollusks, Correction .....*W. P. Popenoe* 163

SOCIETY RECORDS AND ACTIVITIES

Members of the Society of Economic Paleontologists and Mineralogists ..... 164

ERRATUM ..... 170

EDITORS

C. WYTHE COOKE, for the Paleontological Society.

NORMAN D. NEWELL, for the Society of Economic Paleontologists and Mineralogists.

The JOURNAL of PALEONTOLOGY is published bi-monthly. The numbers issued in January, May, and September are sponsored by the Paleontological Society; those issued in March, July, and November are sponsored by the Society of Economic Paleontologists and Mineralogists.

The subscription price of the JOURNAL OF PALEONTOLOGY is $6.00 per year prepaid to addresses in the United States, Mexico, Cuba, Puerto Rico, Panama Canal Zone, Republic of Panama, Dominican Republic, El Salvador, Bolivia, Colombia, Honduras, Nicaragua, Peru, Hawaiian Islands, Philippine Islands, Guam, Samoan Islands.

Single numbers, $2.00 each.

Postage is charged extra: For Canada, 20 cents on annual subscriptions (total $6.20); for all other countries in the Postal Union, 40 cents on annual subscriptions (total $6.40).

The JOURNAL will furnish reprints at cost. Orders should accompany manuscript.

Communications about the JOURNAL, subscriptions, rates, memberships, change of address, and nonreceipt of preceding numbers should be addressed to Society of Economic Paleontologists and Mineralogists, P. O. Box 979, Tulsa, Oklahoma. Claims for nonreceipt of preceding numbers must be sent in within three months of the date of publication in order to be filled gratis. Communications in regard to advertising should be addressed to Norman D. Newell, University of Wisconsin, Madison, Wisconsin.

Communications in regard to manuscripts, or purely editorial matters should be addressed to Norman D. Newell, University of Wisconsin, Madison, Wisconsin, or C. Wythe Cooke, U. S. Geological Survey, Washington, D.C.

Contributors are requested to instruct their photographers to illuminate fossils from the upper left side, the conventional manner. Plates should be arranged for publication at the size of 5 by 7 inches, exclusive of margins, heading, and title. Printed numerals of standard size and form may be obtained free from either editor. When requesting them state number of plates and the dimensions of each plate.

Entered as second-class matter at the Post Office at Tulsa, Oklahoma, under the Act of March 3, 1879. Acceptance for mailing at special rate of postage provided for in paragraph 4, section 538, P. L. and R., authorized April 3, 1935.

Additional entry as second-class matter at the Post Office at Menasha, Wis.

GEORGE BANTA PUBLISHING COMPANY, MENASHA, WIS.

JOURNAL OF PALEONTOLOGY

*A Publication of* THE SOCIETY OF ECONOMIC PALEONTOLOGISTS AND MINERALOGISTS, *A Division of the American Association of Petroleum Geologists and* THE PALEONTOLOGICAL SOCIETY, *An Associate of the Geological Society of America*

VOLUME 14 MARCH, 1940 NUMBER 2

# A NEW CYSTOID FROM THE ORDOVICIAN OF OKLAHOMA

E. B. BRANSON AND RAYMOND E. PECK
University of Missouri, Columbia, Missouri

ABSTRACT—An exceptionally well preserved representative of the Diplorita from the Bromide formation of Oklahoma is figured and described. The species is referred to a new genus, *Eumorphocystis*, and to a new family, the Eumorphocystidae.

THE DISCOVERY by the senior author of a well preserved cystoid with nearly twice as many plates as any hitherto recorded, led the writers to describe and figure it. It was collected from the Bromide formation which contains many cystoid plates but few complete specimens. The specimen was almost clean when taken from the shaly matrix and the only injuries incurred during the later cleaning was in the breaking of two of the deltoid spines. Three expeditions to the same locality have been made for the purpose of securing more specimens, but not even one identifiable plate of this genus has been found.

The illustrations are retouched photographs and were prepared by Vaona H. Peck.

Phylum ECHINODERMA
Class CYSTOIDEA
Order DIPLOPORITA
Family EUMORPHOCYSTIDAE Branson and Peck, new family

Diplorita in which five sub-symmetrical food grooves radiate from the mouth to the outer edge of the oral surface, and thence extend onto the arms. The food grooves are on alternating adambulacrals, most of which are arm-bearing, and each ends on a radial. Diplopores numerous and present on all calyx plates except the deltoids.

Genus EUMORPHOCYSTIS Branson and Peck, new genus

Calyx elongate, sub-cylindrical, possessing a well developed stem facet, four basals, several hundred small polygonal diplopore-bearing plates, five small imperforate deltoids, and five small diplopore-bearing radials. The ambulacra are composed of adambulacrals, brachials, and small cover plates. The mouth is central, the anal opening is on the right side in the posterior interradius, and the genital opening is about half-way between the mouth and the anal opening just outside of the anal deltoid.

EUMORPHOCYSTIS MULTIPORATA Branson and Peck, n. sp.
Plate 13, figures 1–7

The calyx of the holotype is 51 mm long and slightly less than 29 mm in maximum diameter. It consists of a prominent stem facet, four fairly large basals, five small diplopore-bearing radials, five small spine-bearing imperforate deltoids, a variable number of adambulacrals, and more than 500 small polygonals diplopore-bearing calyx plates. The sides of the calyx diverge

gradually from the stem facet to above mid-height, and thence converge to the proximal ends of the ambulacra where they turn sharply inward toward the centrally situated mouth to create a rounded summit. On the calyx are a fairly large oblong mouth opening at the center of the oral surface; an anal opening in an inflated area near the edge of the oral surface on the right side of the posterior interambulacrum; and a small genital opening halfway between the anal opening and the mouth and just back of the proximal edge of the anal deltoid.

The four basals are sub-pentagonal in shape and are the largest plates of the calyx. On the holotype their respective dimensions are: 4.2 mm long by 7 mm wide, 3.6 mm long by 6 mm wide, 3.5 mm long by 5.3 mm wide, and 3.6 mm long by 4.9 mm wide. The smallest plates adjoin and are situated on the anterior and right anterior sides of the calyx. The only diplopore on the basals is on the distal side of the medium sized plate, but several diplopores are present on the sutures at the distal ends of the basals.

The main part of the calyx is composed of small thick polygonal plates which are irregular in size and a variety of shapes. They range in diameter from less than 1 mm to almost 3 mm and are about 1 mm thick. All but a few of the smallest plates bear diplopores and on most of them, diplopores are numerous. Scattered heterogeneously over the calyx, but chiefly in the distal third, are plates that have few diplopores, some of them one, but as many as 15 pores, averaging 0.3 mm in diameter, are present on some of the largest plates. On many of the plates three to seven ridges originate at a central tubercle and radiate out toward the edges.

At the distal ends of the interambulacral areas and closely surrounding the mouth opening are five small imperforate deltoid plates, four of which are triangular in shape, but the one in the anal inter-radius is quadrangular and protrudes into the mouth opening more than any of the others. This protrusion makes the mouth oblong and slightly disturbs the pentameral symmetry of the ambulacral system. On the proximal edge near the middle of each deltoid is a strong spine that curves inward over the mouth. The only unbroken spine is 2 mm in length. The parts of the deltoids not bearing the ambulacral grooves are almost smooth, but on each a series of fine ridges radiates out from the spine.

Five well organized ambulacra radiate from the mouth to the outer margin of the oral surface, from which the food grooves are prolonged onto a variable number of small arms. The ambulacra originate on platforms built up of several small plates that rest on the upper edges of the radials, pass over the inner edges of alternating adambulacrals and thence on apposed edges of the deltoids to the mouth. The areas are slightly depressed from the mouth to the outer edge of the oral surface, but where the calyx turns sharply downward the food grooves extend almost horizontally on the platforms.

The ambulacra are subequal in size and shape, and bear about the same number of arms, but each is somewhat different from every other. None of the ambulacra is complete and near the proximal edges broken and irregular surfaces indicate that arm- or supporting-plates are missing.

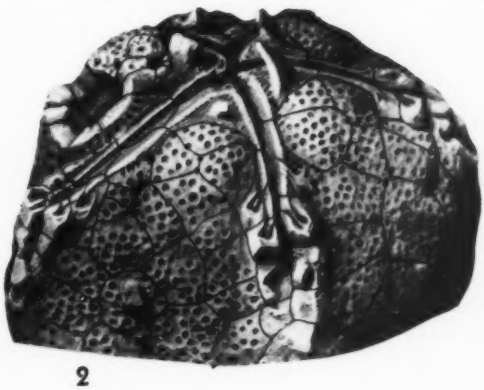
Resting on the distal end of the anterior radial are two quadrangular adambulacral plates which conform to the regular curvature of the calyx, serve as flooring plates for the ambulacral areas and as supports for a radially situated plate that rests partly on them and partly on the faceted distal end of the radial. This plate may have borne a terminal arm. The two proximal adambulacrals differ in length, thus initiating an alternating arrangement of the plates that

---

EXPLANATION OF PLATE 13

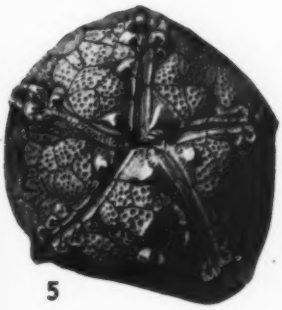
FIGS. *1–7*—*Eumorphocystis multiporata* Branson and Peck, n. gen. and n. sp. *1, 3, 5, 7*, Anterior basal, summit and left posterior views of the holotype, ×1½; *2*, Right anterior view, slightly tilted to show details of ambulacra and construction of platforms for support of ambulacra, ×2½; *4*, Proximal portion of right posterior ambulacrum showing details of food groove and arm facets, ×9; *6*, Left anterior ambulacrum showing details of small plates covering food groove, ×8. (p. 89)

1

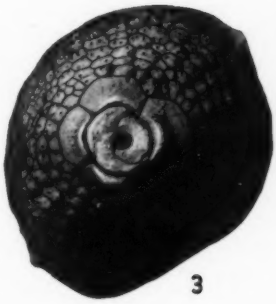


2

4



5



3

6

7

Branson and Peck, Ordovician Cystoid

UNIV. OF MICH.

continues the entire length of the ambulacrum. Against the ends of the first two adambulacrals and in line with them are two nearly square adambulacrals, each of which bears on its upper side another plate that probably functioned as a brachial and bore an arm. On the distal ends of these adambulacrals are two arm-bearing adambulacrals. The one on the right is short, almost square and bears on its distal end a long, somewhat triangular, arm-bearing adambulacral that narrows almost to a point at its distal end where it abuts against the proximal edge of the *R A* deltoid. The plate on the left is fairly long, somewhat triangular, and narrows almost to a point where it joints the next arm-bearing adambulacral distally. This triangular adambulacral attains its greatest width near mid-length where it bears a well developed arm-facet, and narrows almost to a point where it joins the proximal edge of the *L A* deltoid. The anterior adambulacrum has four well developed arm facets preserved, but some of the plates near the proximal border are lost. It probably possessed at least six arms, and possibly eight.

In as far as can be determined the *R A* ambulacrum was like the anterior except that the proximal arm-bearing adambulacral on the left side is quadrangular and does not narrow appreciably at its distal end.

The *L A* ambulacrum has several of the supporting plates preserved near the proximal portion; the distal adambulacral on the left side does not have an arm facet; the food groove is covered with two rows of small plates which alternate in position; and one small concave arm plate is preserved on the distal adambulacral plate on the right. The supporting plates near the proximal border are of unequal size and shape and are wedged together to give a rigid support. The proximal arm-bearing adambulacral has two arm facets, a large one on the outer edge, and a much smaller one on the inner side. This area has only four arm facets preserved, but the arrangement and distribution of the proximal plates indicate that it possessed a minimum of six arms and possibly several more. The distal adambulacral on the left side has a row of small, shallow pits along its outer margin. The pits are connected along their inner side by a shallow groove that seems to have no opening into the main food groove.

The *L P* ambulacrum has more plates preserved than any other area. The adambulacrals are the same in number and arrangement as in the anterior areas. The distal adambulacral adjoining the anal inter-radius has no arm facet but bears a number of small pits connected on their inner sides by a shallow groove that leads into the pit at the base of the arm facet on the adjacent adambulacral on the proximal side. This distal adambulacral also bears two diplopores on its outer side. Small sub-cubical plates at the proximal portion of the ambulacrum form a rigid supporting structure.

The *R P* ambulacral area differs from all others in that there rests on the distal end of the radial a single plate, radial in position, and on its distal end are the two proximal adambulacrals. These adambulacrals are equal in size and bear on their distal ends two adambulacrals of unequal length—the larger one bordering the posterior inter-radius. Next in line are two arm-bearing adambulacrals of unequal size, both square in outline. On the side bordering the anal inter-radius the next distal adambulacral is square and does not bear arms, but does possess diplopores. On its distal end is another quadrangular diplopore-bearing plate that joins the proximal end of the anal deltoid. The proximal adambulacral on the right is small and has the upper surface almost entirely covered by the arm facet. On the distal end it bears a somewhat larger, quadrangular, arm-bearing adambulacral. Next in line is an elongate, triangular, non-arm-bearing adambulacral that extends to the deltoid. This plate bears the small pits with the accompanying groove that leads into the mean food groove and also into the proximal arm pit.

The arm facets have two pits separated by a low ridge. The interior of the facets is about three-fourths of a millimeter wide and each of the divisions is a little more than one-fourth of a millimeter wide. Some of them are more than one-fourth of a millimeter deep. A groove passes along the top of the ridge and opens into the ambulacrum.

From each pit of each facet, excepting the distal, a groove connects with the nearest pit of the adjacent facet. From the distal

facet a groove runs toward the mouth, parallel to the ambulacral groove, and in some areas continues to the spine on the deltoid.

*Occurrence.*—Upper Cystoid zone, about 170 feet above the base of the Bromide formation of the Simpson group (Middle Ordovician) in a road cut on Oklahoma State Highway 90, just west of the center of Sec. 12, T. 1 N., R. 6 E.

*Holotype.*—Catalog number 6757, University of Missouri.

*Remarks.*—The description is based entirely on the holotype which is remarkably well preserved, but has been somewhat compressed, making it impossible to determine the exact diameter.

*Systematic position.*—The advisability of making a new family for the genus *Eumorphocystis* may be considered questionable. An alternate procedure would be to emend the definition of the Protocrinitidae to include this genus. In Bather's (Bather, 1900) classification of the Diplorita the main family characters are the extent and position of the food grooves, the position of the diplopores, and the radial symmetry. The Protocrinitidae possess long branching food grooves bordered by adambulacral plates and the diplopores are confined to the adambulacrals or are diffuse. The family Mesocystidae differs from the Protocrinitidae in the possession of deltoids and in having the diplopores confined to the interambulacrals. Bather considered that the Mesocystidae are an advance over the Protocrinitidae in the direction of the blastoids. Springer (Springer, 1913) combined these two families under the Protocrinitidae, on the basis of long food grooves bordered by adambulacrals. *Eumorphocystis* differs from all members of the Protocrinitidae in having more perfect pentameral symmetry with differentiated basals, radials, and deltoids; and in having short ambulacral areas with the food grooves extending onto well organized arms. The only adambulacrals of *Eumorphocystis* which bear diplopores border the anal area in the *R P* ambulacrum.

According to Bather's classification the Diplorita, in which length and organization of the food grooves play an important part, grade gradually toward the blastoids until, in the Asteroblastidae, pentamerous symmetry is well established and they

> always show defined basals (*B*), and a distinct plate (radial *R*) at the end of each ambulacrum; they are in all cases so far affected with pentamerous symmetry that their sutures never cross the ambulacra (Bather, p. 78, 1900).

In addition *Asteroblastus* has well organized ambulacra, with

> alternating plates, bordered by sockets for the attachment of brachioles. (Ibid.)

*Eumorphocystis* has the required degree of symmetry to be classified with the Protoblastoidea but the ambulacral areas in no way resemble those of a blastoid. On the contrary, the short food grooves, confined to the oral surface and terminated by a distinct radial, and the grouping of arms at the proximal ends of the ambulacral area are features more suggestive of crinoids than blastoids. The large number of diploporebearing, polygonal plates, and the food grooves giving off branches to small arms situated on the adambulacrals are distinctly cystoidean characters.

REFERENCES

BATHER, F. A., *1900*, The Echinodermata: Treatise on Zoology, pt. 3.

SPRINGER, FRANK, *1913*, Cystoidea: Zittel-Eastman Textbook of Paleontology, vol. 1, second edition.

MANUSCRIPT RECEIVED BY THE EDITOR, APRIL 17, 1939.

JOURNAL OF PALEONTOLOGY, VOL. 14, NO. 2, PP. 93–126, PLS. 14–19, MARCH, 1940

# FORAMINIFERA FROM THE GRAYSON FORMATION OF NORTHERN TEXAS[1]

HELEN TAPPAN[2]
Walker Museum, University of Chicago, Chicago, Illinois

ABSTRACT—Ninety species of Foraminifera are herein described from the early Cretaceous Grayson formation of northern Texas and southern Oklahoma, representing more than twice the number of species hitherto listed from this formation. This fauna includes one new genus, 32 new species, and one new variety. Thirty-nine species of the family Lagenidae were found, with 10 of the Polymorphinidae and nine of the Buliminidae. The known geologic range of the genera *Pseudopolymorphina*, *Gümbelitria* and *Shackoina* is here extended into the Lower Cretaceous. The foraminiferal evidence supports that of the ammonites in dating the Grayson formation as Upper Albian in age, and the equivalent of the Albian of France and the Gault of England and Germany.

A NUMBER of the Grayson species were first described in Europe, the most important horizons and localities being the Gault of Folkestone, England, the Albian of Moncley (Doubs), France, and the Hils and Gault of northern Germany. This evidence supports that of the upper Grayson ammonite *Stoliczkaia* in placing the Grayson formation at the upper limit of the Vraconnian.[3] Ninety species of Foraminifera are herein described and illustrated, representing 45 genera and 16 families. These include one new genus, 32 new species, and one new variety.

The writer is indebted to Professor R. W. Harris, under whose direction this work was undertaken as a master's thesis at the University of Oklahoma, for suggestions concerning the identifications, illustrations and descriptions of the specimens and for reading and checking the manuscript. To Dr. C. G. Lalicker, also of the University of Oklahoma, the writer is indebted for the use of paratypes and assistance in identifying the species of the family Textulariidae. The writer also wishes to acknowledge field assistance from her father, F. G. Tappan, and Alfred R. Loeblich in collecting the various samples and in measuring and zoning the outcrops. Mr. Loeblich also assisted in preparing the material for study.

Dr. Joseph A. Cushman, of Sharon, Massachusetts, examined the types, manuscript and plates and gave a number of suggestions many of which have been incorporated in this paper.

The holotypes and all figured specimens, together with a representative set of duplicates are deposited in the collection at the Cushman Laboratory for Foraminiferal Research, Sharon, Mass., and paratypes and representative specimens are deposited at the University of Oklahoma, Norman, Okla., in the Walker Museum of Paleontology at the University of Chicago (U. C. nos. 45000–45084), and in the writer's collection. All species are illustrated with camera lucida drawings made by the writer.

*Description of localities.*—The material upon which this paper is based was collected from several outcrops of the Grayson formation of the Washita group in northern Texas and southern Oklahoma. As all of the holotypes of new species are from a single outcrop, only that section is presented here.

Grayson Bluff is a high, southwest-facing bluff on Denton Creek, three and one-half miles northeast of Roanoke, two miles by road east of the Ft. Worth-Denton highway, Denton County, Texas. This is the best exposed and most complete section of the Grayson formation to be found in northern Texas. There is a total of 60.5 feet exposed. This is the type locality for all of the present new species and also for the species *Valvulineria asterigerinoides* Plummer and *Virgulina minuta* Cushman.

[1] This paper is a portion of a thesis which was presented to the Department of Geology of the University of Oklahoma, as a partial fulfillment of the requirements for the degree of Master of Science.

[2] Mrs. Alfred R. Loeblich.

[3] Scott, Gayle, *1933*, XVI *International Geol. Congress Guidebook* 6, Excursion A-6, Oklahoma and Texas, p. 55.

SECTION OF GRAYSON FORMATION AT GRAYSON BLUFF

| Zone | | Feet |
|---|---|---|
| | Grayson-Woodbine contact. Somewhat obscured by wash from the Woodbine sand. | |
| 1 | Light gray and yellowish marls with thin limestone ledges in the upper part. *Gryphea mucronata* abundant. (Twenty-eight consecutive samples were taken from this zone, each including from one to two feet of section) | 38.5 |
| 2 | Fine-grained yellowish marl. There is a noticeable absence of mollusks in this zone. (Seven consecutive samples were herein obtained, averaging approximately one and one-half feet per sample) | 11.0 |
| 3 | Very fine-grained bluish-gray marl. *Exogyra arietina* occurs toward the base. (Six samples were taken here, each comprising approximately two feet of section) | 11.0 |
| | Main Street-Grayson contact. The heavy Main Street limestone contains *E. arietina*, *Kingena wacoensis* and *Turrilites brazoensis*. | |

SYSTEMATIC DESCRIPTIONS

Family SACCAMMINIDAE

Subfamily SACCAMMININAE

Genus LAGENAMMINA Rhumbler, 1911

LAGENAMMINA PYRIFORMIS Tappan, n. sp.

Plate 14, figures 1a–2

*Reophax ampullacea* CHAPMAN, *1892* (not BRADY, *1884*), Royal Micr. Soc., Jour., p. 320, pl. 5, figs. 2a–b.

Test free, pyriform, wall apparently composed of a chitinous layer with sand grains attached to the surface, occasional specimens having lost the arenaceous layer so that the surface is smooth; short basal spine, which may attain the same length as the neck and in some specimens is apparently hollow; aperture elongate, perhaps due to compression, as the chamber is occasionally also somewhat compressed, neck very elongate, flattened; color white. Total length of holotype, 0.64 mm; length of neck, 0.21 mm; maximum diameter of chamber, 0.31 mm; minimum diameter, 0.20 mm; maximum diameter of neck, 0.06 mm; minimum diameter, 0.03 mm.

*Types.*—Holotype (Cushman Coll. no. 25010) from base of zone 3, paratype (Cushman coll. no 25011) from top of zone 2, Grayson Bluff.

*Remarks.*—This species is somewhat similar to *L. laguncula* Rhumbler, but is more pyriform and has a basal spine. The neck of *L. laguncula* is also arenaceous while that of *L. pyriformis* n. sp. is smooth, although the sand grains may have been worn off as they occasionally are from the entire test. The species ranges throughout the Grayson formation.

Family REOPHACIDAE

Subfamily REOPHACINAE

Genus REOPHAX Montfort, 1808

REOPHAX DECKERI Tappan, n. sp.

Plate 14, figures 3a–b

Test free, elongate, consisting of a series of chambers in a linear and somewhat curved series, adult tests usually compressed; wall rather coarsely arenaceous; aperture single, terminal, at the end of a neck which is about equal in length to the last chamber; reddish to white in color. Length of holotype, 1.06 mm; breadth, 0.39 mm; width, 0.17 mm.

*Types.*—Holotype (Cushman coll. no. 25012) from lower part of zone 1, Grayson Bluff.

*Remarks.*—The Grayson species strongly resembles *R. polyeides* Deecke from the Jurassic, but as the magnification of Deecke's illustrations is not given and the types were not available for comparison, it is impossible to be certain of specific identification. This species ranges throughout the Grayson formation, but is more common in the middle to lower part. The species is named in honor of Dr. C. E. Decker of the University of Oklahoma.

REOPHAX MINUTA Tappan, n. sp.

Plate 14, figures 4a–b

Test small, rectilinear, flattened; early chambers low, increasing in height as added, all chambers depressed centrally or distally, perhaps as a result of collapse, periphery rounded and evenly lobulate; sutures distinct, depressed, horizontal; wall medium to coarsely arenaceous with light gray cement; aperture terminal, slit-like. Length of holotype, 0.615 mm; greatest breadth, 0.16 mm; width, 0.045 mm.

*Type.*—Holotype (Cushman coll. no. 25013) from lower part of zone 1, Grayson Bluff.

*Remarks.*—*Reophax minuta* n. sp. is

similar in general outline to *R. bacillaris* Brady (1884, p. 293) but differs in the much smaller size, centrally depressed chambers and greatly compressed form. The species occurs rather sparingly throughout the Grayson formation.

Genus HAPLOSTICHE Reuss, 1861
HAPLOSTICHE TEXANA (Conrad)
Plate 14, figures 5a–b

*Nodosaria texana* CONRAD, *1857*, Mexican Boundary Survey, vol. 1, pt. 2, p. 159, pl. 14, fig. 4.
*Haplostiche texana* PLUMMER, *1931*, Texas Univ. Bull. 3101, p. 124, pl. 15, fig. 1.
*Cribratina texana* SAMPLE, *1932*, Am. Midland Naturalist, vol. 13, p. 319.

The following description is taken from Plummer (1931 b):

Test large, straight or arcuate, very coarsely arenaceous with considerable cement insoluble in acid; chambers numerous, as many as 15, ventricose, short, stout, strongly overlapping, gradually enlarging from a small blunt aboral extremity in the megalospheric form or from a more acutely pointed initial extremity in the microspheric form; sutures transverse, distinctly but not deeply depressed; shell wall very thick, labyrinthic; aperture typically cribrate at apex of final chamber.

Reddish or yellowish in color. Length of figured specimen, 6.00 mm; maximum diameter, 1.58 mm; minimum diameter, 1.50 mm. The length may vary up to 12.00 mm.

*Type.*—Hypotype (Cushman coll. no. 25014) from middle of zone 1, Grayson Bluff.

*Remarks.*—The species occurs throughout the upper Washita and may range below, being most common in the Del Rio clay of southern Texas and in the Weno formation in nothern Texas. In both of these formations it occurs abundantly on flaggy surfaces. Scattered tests are more common in the upper half of the Grayson formation of northern Texas.

Family AMMODISCIDAE
Subfamily AMMODISCINAE
Genus AMMODISCUS Reuss, 1861
AMMODISCUS GAULTINUS Berthelin
Plate 14, figures 6a–c

*Ammodiscus gaultinus* BERTHELIN, *1880*, Geol. Soc. France, Mem., ser. 3, vol. 1, no. 5, p. 19, pl. 1 (24), figs. 3a–b.
*Ammodiscus gaultinus* EGGER, *1899*, Kön. bay. Akad. Wiss. München, Abhandl., Cl. II, vol. 21, p. 16, pl. 1, figs. 1–3, 8–9, 30–31.
*Ammodiscus gaultinus* CHAPMAN, *1917*, Geol. Survey Western Australia, Bull. 72, p. 18, pl. 1, fig. 8.

Test free, planispiral, discoidal, irregularly circular, especially so in the adult, somewhat enlarged centrally, thinner toward the edges, early portion of coil not visible as it produces the irregular central glomospirine swelling; tube increases gradually in size, slightly overlapping the preceding coil but not completely involute; periphery rounded, surface somewhat irregular, but no sutures present; wall finely arenaceous with much cement; aperture large, slightly higher than wide; color white. Maximum diameter of figured specimen, 0.36 mm; minimum diameter, 0.31 mm; maximum thickness, 0.10 mm; width of tube near aperture, 0.08 mm.

*Type.*—Hypotype (Cushman coll. no. 25015) from bottom of zone 1, Grayson Bluff.

*Remarks.*—This species occurs in the middle and lower Grayson and in the Albian of France and in Western Australia.

Family LITUOLIDAE
Subfamily HAPLOPHRAGMININAE
Genus HAPLOPHRAGMOIDES Cushman, 1910
HAPLOPHRAGMOIDES CONCAVA (Chapman)
Plate 14, figures 7a–c

*Trochammina concava* CHAPMAN, *1892*, Roy. Micr. Soc., Jour., p. 327, pl. 6, figs. 14a–b.

Test free, planispiral, compressed, biumbilicate, periphery slightly rounded; chambers enlarging gradually in size, six in the last whorl, later chambers more rounded giving the periphery a lobulate appearance; sutures radiate, distinct, depressed; wall finely arenaceous, aperture simple at the base of the apertural face of the last chamber; color reddish. Maximum diameter of hypotype, 0.63 mm; minimum diameter, 0.43 mm; maximum thickness, 0.13 mm.

*Type.*—Hypotype (Cushman coll. no. 25016) from base of zone 1, Grayson Bluff.

*Remarks.*—The Grayson species is very similar to that described by Chapman, but as only one view of the holotype was shown by Chapman, and as most of the Gault specimens are distorted, it was not possible to determine whether his species was tro-

choid, and thus a true *Trochammina*, or whether it is really a species of *Haplophragmoides*. However, as he showed only the one view, the latter is probably the case. *H. concava* (Chapman) is somewhat similar to *Trochammina diagonis* (Carsey) in general appearance, but the latter is slightly larger and is trochoid, thus being a true *Trochammina*.

This species ranges throughout the Grayson, although it is somewhat larger in the lower part. It also occurs in the Gault of Folkestone, England.

Genus AMMOBACULITES Cushman, 1910

AMMOBACULITES CUYLERI Tappan, n. sp.
Plate 14, figures 10a–b

Test large, free, much compressed, early chambers somewhat evolute, the earlier coils being visible best when the specimen is dampened, about five chambers in the last coil, uniserial part enlarging very gradually and increasing in relative height as added; sutures straight, distinct, somewhat thickened in the coiled portion, depressed in the straight portion of the test; wall finely arenaceous; aperture narrow, linear, terminal. Length of holotype, 1.41 mm; width across last chamber, 0.49 mm; width across coil, 0.44 mm; thickness through uniserial part, 0.07 mm.

*Type.*—Holotype (Cushman coll. no. 25019) from upper part of zone 1, Grayson Bluff.

*Remarks.*—This species differs from *A. subcretacea* Cushman and Alexander in the greater degree of compression, the more regular size of the chambers, the usually more finely arenaceous wall and the thickened and distinct sutures in the coiled portion. It is more common toward the upper part of the Grayson formation. The species is named in honor of Dr. Robert Cuyler of the University of Texas.

AMMOBACULITES GOODLANDENSIS
Cushman and Alexander
Plate 14, figures 8a–9

*Ammobaculites goodlandensis* CUSHMAN and ALEXANDER, *1930*, Cushman Lab. Foram. Research Contr., vol. 6, pt. 1, p. 8, pl. 2, figs. 7–8.

The following description is from Cushman and Alexander (1930):

Test comparatively large and stout, the earlier portion close coiled, later two or three chambers uncoiled, the earlier portion with the central area depressed and concave, the periphery broad and truncate, the peripheral portions of the chambers broad and raised above the general surface, uncoiled chambers somewhat nodose; sutures indistinct except as marked by the depressions between the chambers; wall of coarse angular fragments with a considerable proportion of light gray cement; aperture elliptical, terminal. Diameter up to 0.90 mm; length up to 1.20 mm.

Length of hypotype in figure 8, 0.80 mm; breadth, 0.58 mm; maximum thickness through chambers, 0.39 mm. Length of specimen showing more complete uniserial development, 0.70 mm, diameter, 0.47 mm.

*Types.*—Hypotype, fig. 8., (Cushman coll. 25017) from the upper part of zone 1; hypotype, fig. 9 (Cushman coll. no. 25018), from middle of zone 1, Grayson Bluff.

*Remarks.*—According to Cushman and Alexander (1930), "This is a large, nodose species, fairly common in this formation (Goodland) and unlikely to be confused with any of the other species of the genus. Most of the specimens are young ones still in the coiled stage, and adult ones showing the complete uncoiled test are comparatively rare." The early coiled portion of *A. goodlandensis* is similar to *Haplophragmium rotulatum* Brady in general size and outline, thick chambers, wide and deeply depressed umbilical area and coarsely arenaceous test differing in the angularly lobulate periphery and the uniserial portion of the test.

The species is fairly common in the Grayson formation as well as throughout the Washita and the Goodland formation.

AMMOBACULITES TESTACEA Tappan, n. sp.
Plate 14, figures 11a–b

Test medium in size, irregularly elongate; chambers flattened in the early coiled portion, six in a complete whorl, later uniserial chambers irregularly inflated; sutures fairly distinct in early portion, obscure in later portion; wall finely arenaceous in the early coiled stage and composed of quartz grains held together with considerable ferruginous cement, coarsely arenaceous in the uniserial portion, with many tests of other foraminifera; aperture terminal, subrounded. Length of holotype, 0.69 mm; breadth across final chamber, 0.26 mm; width, 0.20 mm.

*Type.*—Holotype (Cushman coll. no. 25020) from lower part of zone 1, Grayson Bluff.

*Remarks.*—*A. testacea*, n. sp. is somewhat similar to *Reophax scorpiurus* Montfort in the character of the test, the material used varying from sand grains to spicules and small foraminiferal tests. It differs in possessing a coiled base. The new species is fairly common throughout the Grayson formation.

AMMOBACULITES VARIABILIS Tappan, n. sp.
Plate 14, figures 12a–b

Test elongate, compressed, early portion closely coiled, later portion uniserial and irregularly rectilinear; chambers increasing irregularly in size; sutures distinct, depressed; wall coarsely arenaceous; aperture terminal, elongate, probably due to compression, at the end of a thick neck; color reddish. Length of holotype, 1.115 mm; maximum diameter of coiled portion, 0.20 mm; maximum diameter of uniserial portion, 0.22 mm; minimum diameter of uniserial portion, 0.11 mm.

*Type.*—Holotype (Cushman coll. no. 25021) from middle of zone 1, Grayson Bluff.

*Remarks.*—*A. variabilis*, n. sp., differs from *A. testacea* Tappan, n. sp., in the much more evident and depressed sutures, which give a lobulate appearance to the test, more finely arenaceous test, more closely coiled early portion and lower, more numerous chambers in the uniserial portion. The species occurs throughout the Grayson formation.

Family TEXTULARIIDAE
Subfamily SPIROPLECTAMMININAE
Genus SPIROPLECTAMMINA Cushman, 1927
SPIROPLECTAMMINA AMMOVITREA
Tappan, n. sp.
Plate 14, figures 13a–b

Test tiny, elongate, compressed, coil of early portion slightly enlarged, biserial stage slightly curved and of approximately equal width throughout, margin slightly lobulate to angular; chambers numerous, increasing in height as added, coiled portion consisting of approximately five chambers in the last whorl; sutures fairly distinct, depressed; wall medium to coarsely arenaceous, composed of clear small quartz grains, firmly cemented together; aperture a low arch at the base of the last formed chamber. Length of holotype, 0.45 mm; breadth of coiled portion, 0.11 mm; greatest breadth of biserial portion, 0.12 mm; thickness, 0.065 mm.

*Type.*—Holotype (Cushman coll. no. 25022) from base of zone 3, Grayson Bluff.

*Remarks.*—This species is distinguished by the clear glassy grains which compose the test and by the unusually large coiled portion. It is similar in general outline, large coiled portion and parallel-sided, narrow biserial portion to *Spiroplectoides rosula* (Ehrenberg) but differs in the arenaceous test and more nearly horizontal sutures. It is also similar to *Spiroplectammina bentonensis* Carman in general size and shape, but differs in the more quadrate cross-section and in the chambers which increase more regularly in height. The new species occurs sparingly in the lower Grayson formation.

SPIROPLECTAMMINA LONGA Lalicker
Plate 14, figures 14a–b

*Spiroplectammina longa* LALICKER, *1935*, Cushman Lab. Foram. Research Contr., vol. 11, no. 1, p. 3, pl. 1, figs. 4–5.

The following description is from Lalicker (1935):

Test very elongate, slender, sides nearly parallel for most of the length, somewhat compressed, periphery subacute, greatest width at apertural end; chambers numerous, in the early portion coiled, and for about one-third of the length of the mature form very low, in the remainder of the test higher, averaging over twice the height of the earlier chambers, and more inflated and lobulate; sutures distinct, limbate, more so in the early portion; depressed in the later portion, oblique, forming an angle of 10° to 20° with the horizontal, more oblique in the early portion; wall distinctly arenaceous with considerable proportion of cement and rather smoothly finished; aperture, a high arched opening at the base of the last formed chamber and in a distinct reentrant in the apertural face; color gray. Length of holotype, 0.65 mm; width, 0.18 mm; thickness, 0.10 mm.

The hypotype here figured has a length of 0.64 mm; breadth, 0.20 mm; thickness, 0.09 mm.

*Type.*—Plesiotype (Cushman coll. no. 25023) from lower part of zone 1, Grayson Bluff.

*Remarks.*—According to Lalicker (1935):

*Spiroplectammina mordensis* Wickenden from the Cretaceous of Canada differs from this species by its larger initial end, by a coarsely arenaceous wall, by parallel sides throughout, and a lack of low chambers in the initial one-third of the test. *S. longa* Lalicker is also similar to *S. gaultana* Lalicker, from the Gault of Folkestone, England, but differs in having higher chambers in proportion to their width, more inflated chambers, more elongate test, sides more parallel, and in having a more highly arched aperture.

This species ranges throughout the Washita group and is fairly common in the Grayson formation.

### SPIROPLECTAMMINA NUDA Lalicker
### Plate 14, figures 15a–16

*Spiroplectammina nuda* LALICKER, *1935*, Cushman Lab. Foram. Research Contr., vol. 11, no. 1, p. 4, pl. 1, figs. 6–7.

The following description is from Lalicker (1935).

Test small, tapering, gradually expanding from the rounded initial end, somewhat compressed; chambers numerous, in the early portion coiled, depressed, low and broad, gradually increasing in height as added; sutures strongly limbate, straight, forming an angle of 10° to 15° with the horizontal; wall finely arenaceous, but not smooth; aperture, a low, arched opening at the base of the last-formed chamber. Length of holotype, 0.33 mm; width, 0.20 mm; thickness, 0.08 mm.

The larger specimen here figured has a length of 0.90 mm; breadth, 0.26 mm; thickness, 0.07 mm.

*Types.*—Larger specimen (Cushman coll. no. 25025) from lower part of zone 1, smaller hypotype (Cushman coll. no. 25024) from top of zone 1, Grayson Bluff.

*Remarks.*—According to Lalicker (1935):

This species is characterized by its strongly limbate sutures and relatively low chambers. The general outline of this species is similar to *Textularia washitensis* Carsey but differs in having a coiled initial end, strongly limbate sutures, lower chambers, and straight sutures. In *Spiroplectammina nuda* Lalicker the zigzag line between the chambers is concave upward, while in *Textularia washitensis* Carsey it is convex upward.

*S. nuda* Lalicker differs from *S. longa* Lalicker in the limbate sutures and less thickness, but is of nearly the same size and general appearance. Lalicker records this species from the middle Fort Worth and the Denton formations, and adds that it is rare in both. It is fairly common in the Grayson formation and is apparently much better developed, being of greater length.

## Subfamily TEXTULARIINAE
## Genus TEXTULARIA Defrance, 1824

### TEXTULARIA RIOENSIS Carsey
### Plate 15, figures 1a–2b.

*Textularia rioensis* CARSEY, *1926*, Texas Univ. Bull. 2612, p. 24, pl. 7, fig. 12.
*Textularia conica* CARSEY, *1926* (not D'ORBIGNY) Texas Univ. Bull. 2612, p. 23, pl. 7, fig. 1.
*Textularia rioensis* PLUMMER, *1931*, Texas Univ. Bull. 3101, p. 128, pl. 8, fig. 6.

The following description is from Plummer (1931 b):

Test elongate conical, composed of very fine calcareous particles smoothly finished to slightly rough with considerable cement; chambers low, broad, sutures slightly depressed; periphery very broadly rounded; aperture a low arch at base of septal face . . . . Most specimens show twisting and axial compression, giving rise to a short, broad, conical form that has been designated as *T. conica* from these same strata. Some tests are waxy gray and others exhibit a surface of fine grayish-white calcareous particles.

Length of typical hypotype, 0.62 mm; width, 0.35 mm; thickness, 0.31 mm. Length of short compressed hypotype, of the type called *T. conica* by Carsey, 0.375 mm; width, 0.42 mm, thickness, 0.31 mm.

*Types.*—Typical hypotype (Cushman coll. no. 25026) from top of zone 2, compressed hypotype (Cushman coll. no. 25027) from lower part of zone 1, Grayson Bluff.

*Remarks.*—This species is common both in the Del Rio clay of southern Texas and in the Grayson formation of northern Texas, ranging throughout the Washita group.

### TEXTULARIA WASHITENSIS Carsey
### Plate 15, figures 3–4b

*Textularia washitensis* CARSEY, *1926*, Texas Univ. Bull. 2612, p. 24, pl. 7, fig. 6.
*Textularia washitensis* PLUMMER, *1931*, Texas Univ. Bull. 3101, pp. 127–28, pl. 8, fig. 5.

The following description is from Plummer (1931 b):

Test spatulate, composed of fine and coarse calcareous grains with considerable cement and varying from somewhat smoothly finished to distinctly rough; chambers transverse, polygonal in outline and generally collapsed, leaving sutures as broad and light-colored, blunt, elevated ridges, periphery in early portion of test rather sharp, in

later portion narrowly rounded; aperture typically Textularian.

Color yellowish to white. Length of large hypotype, 1.16 mm; width, 0.43 mm.

*Types.*—Large hypotype (Cushman coll. no. 25028) and smaller hypotype (Cushman coll. no. 25029), both from bottom of zone 1, Grayson Bluff.

*Remarks.*—This species occurs throughout the Washita group and is abundant in the Grayson formation, the specimens averaging slightly larger here than in the underlying formations.

Genus BIGENERINA d'Orbigny, 1826
BIGENERINA WINTONI Cushman and Alexander
Plate 15, figures 5a–b

*Bigenerina wintoni* CUSHMAN and ALEXANDER, *1930*, Cushman Lab. Foram. Research Contr., vol. 6, pt. 1, p. 9, pl. 2, figs. 15a–b.

The following description is from Cushman and Alexander (1930):

Test very elongate, the early portion biserial, much compressed, the broad faces flattened or even slightly concave, later portion very long and nearly cylindrical or slightly increasing in diameter in the earlier portion; chambers of the biserial portion distinct, the middle portion of each somewhat depressed, those of the uniserial cylindrical portion indistinct; sutures of the biserial portion raised and limbate, those of the uniserial portion indistinct; wall coarsely arenaceous, made up of small fragments as well as tests of other Foraminifera with much light gray cement; aperture small, circular, terminal.

Length of hypotype, 1.34 mm; length of biserial portion, 10.6 mm; length of uniserial portion, 0.28 mm; diameter of uniserial portion, 0.27 mm.

*Type.*—Hypotype (Cushman coll. no. 25030) from lower part of zone 1, Grayson Bluff.

*Remarks.*—This species is extremely rare in the Grayson formation, the writer having recovered only four specimens, each from a different sample. The early biserial portion is very similar to *Textularia washitensis* Carsey and may represent a development from that species. The short uniserial portion generally consists of from one to three chambers. The Grayson form differs from the lower Washita form in the much longer biserial portion and much shorter and annulated uniserial portion. In the earlier specimens the uniserial portion is practically cylindrical, the chambers are higher and the aperture smaller. Possibly the four specimens found in the Grayson formation are microspheric ones, for that reason showing the more complete biserial stage.

Family VERNEUILINIDAE
Genus GAUDRYINA d'Orbigny, 1839
GAUDRYINA CUSHMANI Tappan, n. sp.
Plate 15, figures 6a–b

Test large, conical, expanding rapidly from the small base, early portion triserial, and slightly inflated and triangular, later portion biserial; chambers low but broad and wide; sutures fairly distinct, slightly depressed, wall coarsely arenaceous; aperture a low arch at the base of the last chamber, color white. Length of holotype, 0.83 mm; breadth, 0.55 mm; width, 0.40 mm.

*Type.*—Holotype (Cushman coll. no. 25031) from lower part of zone 1, Grayson Bluff.

*Remarks.*—This species is likely to be confused with *Textularia rioensis* Carsey, which is also common in this formation. *G. cushmani* n. sp. differs in the triserial base, lower last chambers which are less rounded above, and a less circular cross-section. *G. cushmani* n. sp. is somewhat similar to young specimens of *G. faujasi* (Reuss) from the Maestrichtian of Holland and the lower Senonian of Germany, but differs in the lower chambers, more circular cross-section and more conical appearance. The new species occurs throughout the Grayson formation.

Genus GAUDRYINELLA Plummer, 1931
GAUDRYINELLA DELRIOENSIS Plummer
Plate 15, figure 7

*Textularia* sp. MARGARET CARPENTER, *1925*, Texas Univ. Bull. 2544, pl. 17, fig. 18.
*Gaudryinella delrioensis* PLUMMER, *1931*, Am. Midland Naturalist, vol. 12, p. 341, text fig. 1a–b; *1931*, Texas Univ. Bull. 3101, p. 137, pl. 9, fig. 13.
*Gaudryinella delrioensis* CUSHMAN, *1937*, Cushman Lab. Foram. Research Contr., Spec. Publ. 7, p. 105, pl. 14, figs. 13–15.

The following description is from Plummer (1931 b):

Test very elongate and slender, rather coarsely agglutinate for its size and composed of large

and small calcareous particles with much cement; earliest chambers in a somewhat compact triserial succession, comprising a small and bluntly pyramidal initial extremity; later chambers biserial grading from an early compact structure of a few rounded chambers through numerous chambers that tend rapidly toward a rectilinear series and become bluntly quadrate posteriorly; senile chambers truly uniserial; sutures very distinct throughout growth and deeply incised; aperture a round opening above the base of the septal face throughout its biserial development and becoming more nearly terminal with advancing age, wholly terminal on uniserial chambers of late maturity. Length up to 1 mm. at type locality; average length about 0.6 mm.

Length of figured specimen 0.77 mm; width of final chamber 0.16 mm.

*Type.*—Hypotype (Cushman coll. no. 25032) from top of zone 2, Grayson Bluff.

*Remarks.*—This species occurs throughout the Washita and is fairly common throughout. It is of smaller size in the upper Grayson of northern Texas than in the lower Grayson and underlying formations. It is especially well developed in the Del Rio clay of southern Texas.

Family MILIOLIDAE
Genus MASSILINA Schlumberger, 1893
MASSILINA PLANOCONVEXA Tappan, n. sp.
Plate 15, figures 8a–c

Test medium in size, early chambers quinqueloculine and protruding somewhat on one side, other side flat, later chambers added on opposite sides in a single plane; sutures distinct, limbate, clear, remainder of shell chalky white in appearance; wall calcareous, imperforate; aperture simple. Length of holotype 0.56 mm; width 0.33 mm; thickness 0.16 mm.

*Type.*—Holotype (Cushman coll. no. 25033) from lower part of zone 1, Grayson Bluff.

*Remarks.*—*M. planoconvexa*, n. sp. is somewhat similar in appearance to *Spiroloculina depressa* d'Orbigny from the Recent. It differs in the protruding early quinqueloculine stage, the more rounded periphery, the clear, thickened sutures and in the more even width of the chambers. *M. planoconvexa* is somewhat larger and flatter than the undescribed species commonly found in the lower Washita. The latter is more triangular in cross section and is smaller in size.

The species occurs throughout the Grayson formation.

Family PLACOPSILINIDAE
Subfamily PLACOPSILININAE
Genus PLACOPSILINA d'Orbigny, 1850
PLACOPSILINA LONGA Tappan, n. sp.
Plate 15, figures 9a–10

Test attached, composed of numerous chambers, early portion close coiled, later portion uncoiled and becoming rectilinear, last chambers sometimes growing upward from the attachment, occasionally very long forms are found which are apparently attached throughout their length; chambers large, only about five to a coil, large umbilical plug present which protrudes above the rest of the chambers but is occasionally broken out; early uniserial chambers rather short, later ones lengthening somewhat, but not as long as broad; sutures distinct, depressed, nearly straight to slightly curved; wall coarsely arenaceous with considerable cement; aperture semicircular when last chamber is attached, becoming rounded when the last chamber has grown upward and away from the attachment. Length of holotype 1.05 mm; width across last chamber, 0.49 mm; width across coiled portion, 0.54 mm; thickness through last chamber, 0.29 mm; thickness through center of umbilical plug, 0.30 mm; greatest diameter of umbilical plug, 0.22 mm.

*Type.*—Holotype (Cushman coll. no. 25034) from middle part of zone 1, paratype (Cushman coll. no. 25035) also from middle part of zone 1, Grayson Bluff.

*Remarks.*—This species is of unusually great length. According to Galloway (1933), the genus may attain a length up to five millimeters. The specimen in figure 10 has a length of 5.56 mm. *P. longa* n. sp. differs from *P. rotaliformis* Deecke in its much larger initial coiled portion, as compared to the breadth of the later chambers, the more regular size of the chambers in the coiled portion, the larger umbilical plug, the lower height of the chambers of the uniserial portion and their more regular size throughout the entire length. The early stage of *P. longa* n. sp. is somewhat similar to the specimen figured by Chapman as *P. cenomana* d'Orbigny and may be identical. However, that figured by Reuss as *P. cenomana* is a

much more irregular form, especially in the coiled stage. This form also lacks the umbilical plug which is characteristic of *P. longa*. As the original specimen of d'Orbigny was not available, it is not certain whether that figured by Reuss or by Chapman was closer to the original. *P. longa* is distinguished by its great length.

This species is fairly common, frequently being attached to pelecypod fragments.

Family LAGENIDAE
Subfamily NODOSARIINAE
Genus LENTICULINA Lamarck, 1804
LENTICULINA GAULTINA (Berthelin)
Plate 15, figures 11a–b

*Cristellaria gaultina* BERTHELIN, *1880*, Geol. Soc. France, Mem., ser. 3, vol. 1, mem. 5, p. 49, pl. 3 (26), figs. 15–19.
*Cristellaria gaultina* CHAPMAN, *1896*, Roy. Micr. Soc., Jour., pp. 7–8, pl. 1, figs. 10a–b, 11.
*Cristellaria gaultina* EGGER, *1899*, Kön. bayer. Akad. Wiss. München. Abhandl., Cl. 2, vol. 21, p. 121, pl. 23, figs. 23–24.
*Cristellaria gaultina* CHAPMAN, *1917*, Geol. Survey West. Australia, Bull. 72, p. 38, pl. 9, fig. 85.
*Cristellaria washitensis* CARSEY, *1926*, Texas Univ. Bull. 2612, p. 38, pl. 7, fig. 9.
*Lenticulina washitensis* PLUMMER, 1931, Texas Univ. Bull. 3101, p. 142, pl. 11, fig. 19.
*Robulus gaultinus* EICHENBERG, *1934*, 26 Niedersächs geol. Ver., Jahrb., folge 3, p. 156, pl. 16, fig. 6.

The following description is from Plummer (1931 b):

Test lenticular, slightly elongate and wholly involute, thinly keeled, strongly umbonate, peripheral outline evenly rounded; chambers from 10 to 13 to mature convolution, uninflated; sutures smooth or slightly elevated around the umbonal area, almost straight and somewhat oblique; aperture radiate on periphery. Greatest diameter of holotype, 0.6 mm; lesser diameter, 0.5 mm; thickness through center, 0.25 mm.

*Type.*—Hypotype (Cushman coll. no. 25036) from top of zone 1, Grayson Bluff.

*Remarks.*—According to Plummer (1931 b):

The body of this species merges by direct slope from the central umbonal area into the thick sharp flange which on most specimens is unbroken and broad. A few tests bear only a sharp keel without the extended flange. Rare senile tests exhibit a final astacoline chamber that fails to reach back to the central portion of the test.

*L. gaultina* has been recorded from France, Germany, England and western Australia. *L. washitensis* (Carsey) is so similar that it is considered to be the same species. This species is common throughout the Washita group, especially large and well developed forms occurring in the Grayson formation.

Genus MARGINULINA d'Orbigny, 1826
MARGINULINA sp. A
Plate 15, figures 12a–b

Test somewhat elongate, coiled in the early stage, tending to become uniserial; chambers oval in cross-section, increasing very little in height as added until the final chamber which is very high; sutures indistinct, not depressed; wall calcareous, smooth; aperture simple, radiate, terminal. Length of figured specimen, 0.53 mm; breadth, 0.23 mm; width, 0.17 mm.

*Type.*—Figured specimen (Cushman coll. no. 25037) from top of zone 2, Grayson Bluff.

*Remarks.*—Both this and the following species of *Marginulina* are such simple and unornamented forms that specific identification is difficult. For the present they are neither referred to a previously described or new species.

MARGINULINA sp. B
Plate 15, figures 13a–c

*Cristellaria bronni* REUSS, *1863* (not ROEMER), Akad. Wiss. Wien., Sitz., vol. 46, p. 70, pl. 7, fig. 13.

Test short, thick, subcylindrical, inflated, early portion close-coiled, later uncoiled, dorsal margin sharper, giving the later portion an ovate cross-section; sutures slightly depressed, fairly distinct, early ones curved, becoming less curved as added; wall calcareous, smooth; aperture at the peripheral angle. Length of figured specimen, 0.44 mm; width, 0.25 mm; thickness across apertural face, 0.19 mm.

*Type.*—Figured specimen (Cushman coll. no. 25038) from lower part of zone 1, Grayson Bluff.

MARGINULINA TENUISSIMA Reuss
Plate 17, figures 9–10

*Marginulina tenuissima* REUSS, *1863*, Akad. Wiss. Wien., Sitz., vol. 46, p. 61, pl. 5, fig 18; pl. 12, fig. 12.

*Marginulina tenuissima* CHAPMAN, *1894*, Roy. Micr. Soc., Jour., p. 162, pl. 4, fig. 19.
*Marginulina tenuissima* EGGER, *1899*, Kön. bayer Akad. Wiss. München, Abhandl., Cl. 2, vol. 21, p. 97, pl. 10, fig. 23.
*Marginulina* sp. EICHENBERG, *1933*, Foram. d. norddeutschen Erdölfelden, Teil I, Folge 3, p. 161, pl. 11, fig. 19.

Test long, slender, straight or slightly curved, slightly coiled at the base; chambers slightly inflated; sutures distinct, depressed; wall calcareous, surface ornamented with 12 to 14 narrow, low longitudinal ribs, which twist slightly about the test; aperture radiate, at the end of a slight neck at the dorsal angle. Length of large hypotype, 1.20 mm; width, 0.17 mm; length of small figured specimen, 0.54 mm; width, 0.12 mm.

*Type.*—Large hypotype (Cushman coll. no. 25073) from base of zone 1, small hypotype (Cushman coll. no. 25074) also from base of zone 1, Grayson Bluff.

*Remarks.*—This species was first described from Germany and has been recorded from England. It ranges throughout the Washita group and is fairly common in the Grayson formation.

### Genus DENTALINA d'Orbigny, 1826
### DENTALINA COMMUNIS (d'Orbigny)
### Plate 16, figure 1

*Nodosaria (Dentalina) communis* D'ORBIGNY, *1826*, Annals and Mag. Nat. History, vol. 7, p. 254, no. 35.
*Nodosaria communis* CARSEY, *1926*, Texas Univ. Bull. 2612, p. 34, pl. 7, fig. 5.
*Dentalina communis* PLUMMER, *1931*, Texas Univ. Bull. 3101, p. 149, pl. 11, fig. 4.
*Dentalina communis* EICHENBERG, *1933*, Niedersächs geol. Ver. Jahresber. 25, Folge 2, p. 185, pl. 19, fig. 3; pl. 21, fig. 7; *1935*, Roemer-Mus., Mitteil, No. 37, Folge 4, p. 19, pl. 1, fig. 24.

Test elongate, tapering, somewhat curved; chambers more inflated toward apertural end; sutures oblique, distinct, depressed; wall calcareous, smooth; aperture terminal, radiate. Length of hypotype 1.03 mm; width, 0.14 mm.

*Type.*—Hypotype (Cushman coll. no. 25039) from middle of zone 1, Grayson Bluff.

*Remarks.*—This species has been recorded from many horizons from Cretaceous to Recent. Only a very limited synonymy is given here. This species occurs commonly in the Grayson formation and has been recorded generally throughout the Cretaceous of Texas.

### DENTALINA CYLINDROIDES Reuss
### Plate 16, figure 2

*Dentalina cylindroides* REUSS, *1860*, Akad. Wiss. Wien., Sitz., vol. 40, p. 185, pl. 1, fig. 8.
*Nodosaria (Dentalina) cylindroides* CHAPMAN, *1893*, Roy. Micr. Soc., Jour., p. 589, pl. 8, fig. 34.
*Dentalina cylindroides* EICHENBERG, *1935*, Roemer-Mus., Mitteil., no. 37, Folge 4, p. 17, pl. 1, fig. 16.

Test large, thick, cylindrical, gradually tapering, slightly curved, chambers rounded; sutures slightly depressed, not very distinct; wall calcareous, smooth; aperture terminal, radiate. Length of hypotype, 1.29 mm; width, 0.24 mm.

*Type.*—Hypotype (Cushman coll. no. 25040) from bottom of zone 1, Grayson Bluff.

*Remarks.*—This species is fairly common throughout the Grayson formation.

### DENTALINA HAMMENSIS (Franke)
### Plate 16, figure 3.

*Marginulina hammensis* FRANKE, *1928*, Preuss. geol. Landesanstalt., Abh., n. ser., vol. 111, p. 77, pl. 7, fig. 9.

Test medium in size, elongate, but slightly arcuate, fairly straight backed; proloculum globular with chambers inflated and increasing in height as added, last chambers tending to become slightly irregular, periphery lobulate; sutures distinctly oblique, depressed; wall calcareous, entire surface finely hispid; aperture radiate, terminal, produced at the end of a slight neck. Length of hypotype, 1.01 mm; width of last chamber, 0.155 mm; width of proloculum, 0.125 mm.

*Type.*—Hypotype (Cushman coll. no. 25041) from lower part of zone 2, Grayson Bluff. The species is fairly common in the lower Grayson.

### DENTALINA sp.
### Plate 16, figures 4a–b

*Nodosaria filiformis* CARSEY, *1926* (not d'ORBIGNY), Texas Univ. Bull. 2612, p. 33, pl. 7, fig. 8.

Test long, slender, smooth, somewhat curved; chambers elongate, about twice as long as broad; sutures depressed, slightly

oblique; wall calcareous, smooth; aperture terminal, radiate. Length of figured specimen, 0.57 mm; width, 0.135 mm.

*Type.*—Figured specimen (Cushman coll. no. 25042) from bottom of zone 1, Grayson Bluff.

*Remarks.*—Only fragments of this species are found, usually two or three chambers in a fragment. These were not considered complete enough for specific identification.

### Genus NODOSARIA Lamarck, 1812
### NODOSARIA AMPHIOXYS Reuss
### Plate 16, figure 12

*Nodosaria amphioxys* REUSS, *1873*, Palaeontographica, vol. 20, pt. 2, p. 82, pl. 1, fig. 2.
*Nodosaria amphioxys* FRANKE, *1928*, Preuss. geol. Landesanstalt, Abh., n. ser., vol. 111, p. 48, pl. 4, fig. 2.
*Nodosaria amphioxys* EICHENBERG, *1933*, 25 Niedersächs geol. Ver. Jahresber., 25, p. 182, pl. 18, fig. 9.

Test small, straight, tapering gradually; chambers inflated at the base, tapering toward the aperture, one and one-half to two times as long as broad, increasing gradually in size as added; sutures distinct, depressed; wall calcareous, with longitudinal ribs, about 18 in number and somewhat ragged; aperture terminal, radiate, at the end of a rather long neck which is occasionally broken. Length of hypotype, 0.64 mm; width, 0.13 mm.

*Type.*—Hypotype (Cushman coll. no. 25050) from base of zone 1, Grayson Bluff.

*Remarks.*—This species has been recorded from England and Germany and occurs throughout the Grayson formation of Texas. *N. amphioxys* Reuss differs from *N. obscura* Reuss in its smaller size, more numerous ribs, more distinct sutures, and basally inflated chambers.

### NODOSARIA BIFURCATA Tappan, n. sp.
### Plate 16, figures 5a–b

Test small, subcylindrical, tapering only slightly; chambers increasing in height as, added, not much inflated; sutures distinct, slightly depressed; wall calcareous, apical spine at base, rest of surface ornamented with about 16 low, thin smooth ribs, bifurcating as the test increases in width and twisting slightly; aperture terminal, radial, on a short neck. Length of holotype, 0.55 mm; width 0.115 mm.

*Type.*—Holotype (Cushman coll. no. 25043) from base of zone 1, Grayson Bluff.

*Remarks.*—This species is similar to *N. fontannesi* Reuss (not Berthelin) in the character of the ribs and their bifurcation, but is much smaller, has a shorter neck, shorter chambers and much more distinct sutures. It is also similar to *N. alternistriata* Morrow (1934, p. 190) from the basal Niobrara, in general outline, apertural portion and bifurcating costae, but differs in the slightly smaller size, more uniform costae and more irregular size of the chambers, which average less in height than those of *N. alternistriata*.

### NODOSARIA CHAPMANI Tappan, n. sp.
### Plate 16, figures 9–10

*Nodosaria orthopleura* CHAPMAN, *1893* (not REUSS, 1863), Roy. Micr. Soc., Jour., p. 595, pl. 7 (9), figs. 22–23.
*Nodosaria prismatica* var. *orthopleura* FRANKE, *1928*, Preuss. geol. Landesanstalt, Abh., n. ser., vol. 111, p. 48, pl. 4, figs. 12a–b.
*Nodosaria orthopleura* EICHENBERG, *1933*, Niedersächs geol. Ver. Jahresber., 25, p. 4, pl. 5, fig. 5.

Test very long, slender, straight, tapering gradually, apex pointed; chambers somewhat inflated, about twice as long as broad, sutures distinct, depressed; wall calcareous, surface ornamented with five or six very straight thin ribs which are frequently ragged on the edges; aperture terminal, radial at the end of a long neck. Length of holotype, 1.98 mm; width, 0.19 mm; length of paratype, 0.51 mm; width, 0.09 mm.

*Types.*—Holotype (Cushman coll. no. 25047) from top of zone 2, paratype (Cushman coll. no. 25048) from bottom of zone 1, Grayson, Bluff.

*Remarks.*—Due to the length of this species and the slender form, most of the specimens are broken. The holotype is an unusually complete specimen of the adult stage. *N. chapmani* n. sp. differs from *N. orthopleura* Reuss (1863 a, p. 89), in the thinner and more fragile ribs, less depressed sutures, higher and more inflated chambers and longer neck. It is also somewhat similar to *N. navarroana* Cushman (1937 e, p. 103) in the smooth chambers and straight ribs, which are about four to five in number, but differs in the much more elongated chambers and their more uniform size, in the long

neck, and the much thinner and more produced ribs, which are characteristically somewhat ragged in appearance.

### NODOSARIA LEPIDA Reuss
Plate 16, figures 6a–b

*Nodosaria lepida* REUSS, *1860*, Akad. Wiss. Wien., Sitz., vol. 40, p. 178, pl. 1, fig. 2.
*Ellipsonodosaria lepida* FRANKE, *1928*, Preuss. geol. Landes., Abh., n. ser., vol. 111, p. 55, pl. 4, figs. 29–30.
*Ellipsonodosaria lepida* EICHENBERG, *1935*, Roemer-Mus., Mitteil., no. 37, Folge 4, p. 30, pl. 2, fig. 4.

Test elongate, faintly curved; consists of six to eight chambers that increase in height as added, early chambers practically cylindrical, final chamber flask-shaped; sutures but faintly depressed in early portion, later ones distinctly depressed; wall calcareous, smooth, hyaline; aperture terminal, apparently radiate, at the end of a short neck. Length of hypotype, 0.72 mm.; diameter, 0.135 mm.

*Type.*—Hypotype (Cushman coll. no. 25044) from middle of zone 2, Grayson Bluff. This species occurs sparingly in the lower Grayson formation.

### NODOSARIA OBSCURA Reuss
Plate 16, figures 7a–8b

*Nodosaria obscura* REUSS, *1845–46*, Verstein. bohm. Kreidef., pt. 1, p. 26, pl. 13, figs. 7–9.
*Dentalina inepta* REUSS, *1863*, Akad. Wiss. Wien., Sitz., vol. 46, p. 40, pl. 2, fig. 13.
*Nodosaria obscura* REUSS, *1874*, Palaeontographica, vol. 20, pt. 2, p. 86, pl. 20, figs. 1–4.
*Nodosaria obscura* BERTHELIN, *1880*, Soc. Géol. France, Mém., ser. 3, vol. 1, mem. 5, p. 31, pl. 1 (24), figs. 17a–b.
*Dentalina Fontannesi* BERTHELIN, *1880*, Ibid., p. 42, pl. 2 (25), figs. 14–15 (not 16).
*Nodosaria obscura* BURROWS, SHERBORN and BAILEY, *1890*, Roy. Micr. Soc., Jour., pt. 5, p. 557, pl. 9, fig. 24.
*Nodosaria obscura* CHAPMAN, *1893*, Roy. Micr. Soc., Jour., p. 593, pl. 9, fig. 16 (erroneously fig. 15 on plate).
*Nodosaria obscura* EGGER, *1899*, Bay. Akad. Wiss. München, Abh., Cl. II, vol. 21, p. 75, pl. 24, fig. 23.
*Nodosaria obscura* HERON-ALLEN and EARLAND, *1910*, Roy. Micr. Soc., Jour., p. 418, pl. 7, fig. 7.
*Nodosaria obscura* CUSHMAN, *1926*, Cushman Lab. Foram. Research, Contr., vol. 2, pt. 1, p. 20, pl. 2, fig. 8.
*Nodosaria fragilis* CARSEY, *1926*, Texas Univ. Bull. 2612, p. 35, pl. 4, fig. 1.
*Nodosaria raphanus* var. *obscura* FRANKE, *1928*, Abh. preuss. geol. Landes., n. ser., vol. 111, pt. 3, p. 48, pl. 4, fig. 5.
*Nodosaria obscura* PLUMMER, *1931*, Texas Univ. Bull. 3101, p. 156, pl. 11, fig. 3.

The following description is from Plummer (1931 b):

Test straight, short, stout, composed of a few cylindrical to very slightly inflated chambers ornamented by seven to nine very thin and highly elevated longitudinal ribs that extend from a sharp apical spine to the oral extremity of the test; aperture at end of a prominent slender tube that projects from the end of the final chamber. . . . The few costae are very thin and fragile and are highly elevated above the chambers and across the sutures, consequently in fossil condition they are characteristically ragged. One salient feature of this short, straight, ribbed test is the long tubular apertural extension that is similar to that of many well-known species of *Lagena* but much more rare amongst the *Nodosariae*. This delicate feature is naturally broken from most of the tests, but even the hole at the end of the last chamber with its ragged rim is diagnostic.

Length of hypotype in figure 7, 0.76 mm; width, 0.24 mm; length of hypotype in figure 8, 0.74 mm; width, 0.16 mm; length of neck, 0.10 mm.

*Types.*—Hypotype in figure 7, (Cushman coll. no. 25045) and hypotype in figure 8 (Cushman coll. no. 25046) are both from the middle part of zone 1, Grayson Bluff.

*Remarks.*—This species has been recorded from Germany, France and England and from strata throughout the Cretaceous in many other places. It is common in the Del Rio and Grayson and ranges throughout the Washita group, although it is less common in the lower formations.

### NODOSARIA PAUPERCULA Reuss
Plate 16, figure 11

*Nodosaria paupercula* REUSS, *1845–46*, Verstein. böhm. Kreidef., pt. 1, p. 26, pl. 12, fig. 12; *1874*, Palaeontographica, vol. 20, pt. 2, p. 81, pl. 20, figs. 5–7.
*Dentalina paupercula* BERTHELIN, *1880*, Soc. Géol. France, Mém., ser. 3, vol. 1, mem. 5, p. 43, pl. 2 (25), fig. 17.
*Nodosaria paupercula* CHAPMAN, *1893*, Roy. Micr. Soc., Jour., p. 593, pl. 7 (9), figs. 13–14.
*Nodosaria paupercula* EGGER, *1899*, Bayer. Akad. Wiss. München, Abh., Cl. II, vol. 21, p. 72, pl. 8, fig. 7.
*Nodosaria* (*Dentalina*) *paupercula* CHAPMAN, *1917*, Geol. Survey Western Australia, Bull. 72, p. 27, pl. 4, fig. 41.
*Nodosaria pauperata* EICHENBERG, *1933*, Nieder-

sächs geol. Vereins, Jahrb., Folge 2, p. 180, pl. 18, fig. 6.
*Nodosaria paupercula* EICHENBERG, *1934*, Niedersächs geol. Ver. Jahresber., 25, p. 173, pl. 15, fig. 4.

Test medium in size, slightly curved; chambers much inflated, globular, increasing gradually in size; sutures distinct and much depressed; wall calcareous, ornamented with 20 to 25 low rounded ribs; aperture terminal, radiate. Length of hypotype, 0.54 mm; width, 0.16 mm.

*Type.*—Hypotype (Cushman coll. no. 25049) from bottom of zone 1, Grayson Bluff.

*Remarks.*—This species differs from the other uniserial, ribbed species in the Grayson formation in the globular chambers, low smooth ribs and slightly curved axis. Due to the constrictions between the chambers, complete tests are rare, most specimens having but two or three chambers in a fragment. This species has been recorded from England, France and Germany and is fairly common in the Grayson formation.

Genus PSEUDOGLANDULINA Cushman, 1929

PSEUDOGLANDULINA cf. MUTABILIS (Reuss)

Plate 16, figures 15a–b

*Glandulina mutabilis* REUSS, *1863*, Akad. Wiss. Wien., Sitz., vol. 46, p. 58, pl. 5, figs. 7–11.
*Glandulina mutabilis* BERTHELIN, *1880*, Soc. géol. France, Mém., ser. 3, vol. 1, mem. 5, p. 45.
*Glandulina mutabilis* EGGER, *1899*, Bayer. Akad. Wiss. München, Abh., Cl. II, vol. 21, p. 83, pl. 5, figs. 21, 29.

Test medium in size, chambers increasing rapidly in size, round in cross-section, often slightly flattened toward the apertural end, last chamber equal to one-half the length; sutures distinct, slightly depressed; wall calcareous, smooth; aperture terminal, radiate. Length of figured specimen, 0.45 mm; width, 0.23 mm; length of last chamber 0.24 mm.

*Type.*—Hypotype (Cushman coll. no. 25053) from middle of zone 1, Grayson Bluff.

*Remarks.*—This species is referred tentatively to that of Reuss, but as the magnification of his illustrations is not given, the specific identification is not certain.

PSEUDOGLANDULINA SCOTTI Tappan, n. sp.

Plate 16, figures 13a–b

Test long, slightly irregularly lineate, early chambers expanding rapidly, rest of test subcylindrical; chambers increasing in height as added, last chamber being equal to one-fifth of the entire length; sutures distinct, slightly depressed, nearly straight; wall calcareous, smooth; aperture radiate, terminal. Length of holotype, 0.77 mm; width, 0.20 mm; length of last chamber 0.15 mm.

*Type.*—Holotype (Cushman coll. no. 25051) from bottom of zone 1, Grayson Bluff.

*Remarks.*—This species differs from *P. mutabilis* (Reuss) in its much greater length as compared to the other dimensions, and in its rapidly tapering base. It is somewhat questionably referred to the genus *Pseudoglandulina* as it has a much more slender form than the typical species of that genus. This species is named for Dr. Gayle Scott of Texas Christian University, Fort Worth, Texas, in recognition of his work on the Texas Lower Cretaceous.

PSEUDOGLANDULINA sp.

Plate 16, figures 14a–b

Test minute, straight, somewhat flattened, expanding rapidly, only a small part of the early chambers being visible, the last chamber comprising about one-half of the entire length; sutures distinct, depressed; wall calcareous, smooth; aperture terminal, radiate, slightly slit-like. Length of figured specimen, 0.25 mm; width, 0.13 mm; length of last chamber, 0.14 mm.

*Type.*—Figured specimen (Cushman coll. no. 25052) from middle part of zone 1, Grayson Bluff.

*Remarks.*—This species differs from *P.* cf. *mutabilis* (Reuss) in the smaller size, less inflated chambers and basal tapering.

Genus SARACENARIA Defrance, 1824

SARACENARIA BONONIENSIS (Berthelin)

Plate 16, figures 16a–b

*Cristellaria bononiensis* BERTHELIN, *1880*, Soc. géol. France, Mém., ser. 3, vol. 1, mem. 5, p. 55, pl. 3 (26), figs. 23a–c.
*Cristellaria bononiensis* CHAPMAN, *1894*, Roy. Micr. Soc., Journ., pp. 652–653, pl. 10, figs. 9a–b.

Not *Cristellaria bononiensis* EGGER, *1899*, Bayer Akad. Wiss. München, Abh., Cl. 2, vol. 21, p. 112, pl. 25, figs. 4–6.

Test small, triangular in cross-section, early portion tightly coiled, later tending to become rectilinear; chambers increasing rapidly in size; sutures slightly curved, convex upward, distinct, very slightly depressed on the sides but deeply depressed on the ventral face, giving a slightly lobulate periphery; wall calcareous, smooth, except for a carinate rib along the dorsal angle, one down the center of the ventral face and one down each margin of the ventral face; aperture radiate, at the peripheral angle, median ventral slit slightly enlarged. Length of hypotype, 0.45 mm; width across apertural face, 0.13 mm.

*Type.*—Hypotype (Cushman coll. no. 25054) from middle of zone 1, Grayson Bluff.

*Remarks.*—This species is characterized by the median rib on the ventral face and the triangular cross-section. It occurs throughout the Washita group and is fairly common in the Grayson formation.

SARACENARIA CUSHMANI
Tappan, n. sp.
Plate 16, figures 17a–b

*Cristellaria sulcifera* CHAPMAN, *1894* (not REUSS, *1863*), Roy. Micr. Soc., Journ., pp. 650–651, pl. 10, figs. 2a–b.

Test medium to small in size, close coiled at the base, later chambers tending to uncoil, triangular in cross-section; chambers inflated just in front of the depressed sutures, so that without careful observation the sutures appear limbate; peripheral keel present, sometimes broken to give a ragged appearance, test slightly umbonate; wall calcareous; aperture radiate, at the peripheral angle, apertural face wide. Length of holotype, 0.45 mm; maximum width across coil, 0.15 mm; breadth across uncoiled portion, 0.21 mm; width, 0.18 mm; width through center of coiled portion, 0.11 mm.

*Type.*—Holotype (Cushman coll. no. 25055) from base of zone 3, Grayson Bluff.

*Remarks.*—This species occurs throughout the Washita and is present throughout the Grayson formation, although not very abundant. It differs from *Cristellaria sulcifera* Reuss (1863, p. 74) in the wider apertural face, much higher last chambers, peripheral keel and sharper ribs along the sutures. The chambers also increase much more rapidly in height.

Genus LINGULINA d'Orbigny, 1826
LINGULINA FURCILLATA Berthelin
Plate 16, figures 18a–c

*Lingulina furcillata* BERTHELIN, *1880*, Soc. géol. France, Mém., Ser. 3, vol. 1, Mem. 5, p. 65, pl. 4 (27), figs. 6a–c.

? *Lingulina furcillata* EGGER, *1899*, Bayer. Akad. Wiss. München, Abh., Cl. 2, vol. 21, p. 85, pl. 23, figs. 28–30. (Doubtfully synonymous.)

Test elongate, uniserial, compressed, somewhat irregularly lineate, chambers highly arched in the center, inflated centrally, edges sharply angular, sides nearly parallel; sutures distinct, depressed, highly arched in an acute angle; wall calcareous, smooth; aperture elongate, terminal, slit-like. Length of hypotype, 0.48 mm; width, 0.13 mm; thickness, 0.07 mm.

*Type.*—Hypotype (Cushman coll. no. 25056) from base of zone 1, Grayson Bluff.

*Remarks.*—The Grayson species is characterized by its long parallel sides and highly arched sutures. The edges may be slightly sharper and the sutures more highly arched and acutely angled than Berthelin's species. However, the suture curvature of the final chamber agrees with the curvature of his species. *L. furcillata* is fairly common in the Grayson formation.

LINGULINA LAMELLATA Tappan, n. sp.
Plate 16, figure 19

Test short, flattened, much compressed, chambers V-shaped, similar to those of *Frondicularia*, thickest centrally, early chambers narrow, flaring suddenly and then enlarging gradually for the remainder of the length; sutures distinct, depressed, highly arched; wall calcareous, smooth, margins slightly lobulate due to the depressed sutures; aperture terminal, elongate, slit-like. Length of holotype, 0.34 mm; width, 0.19 mm.

*Type.*—Holotype (Cushman coll. no. 25057) from lower part of zone 1, Grayson Bluff.

*Remarks.*—This species is similar to *L. furcillata* Berthelin, but differs in the

smaller, shorter, broader and abruptly flaring test, and the more rounded, less acutely curved sutures. It is very similar to *L. taylorana* Cushman (1938 b, p. 43) in general outline and compressed form, but differs in the more acute sutures, narrower early chambers and abrupt flaring and in the absence of the thin flanges at the basal angles of the chambers.

### LINGULINA NODOSARIA Reuss
Plate 16, figures 20a–b

*Lingulina nodosaria* REUSS, *1863*, Akad. Wiss. Wien., Sitz., vol. 46, p. 59, pl. 5, fig. 12.
*Lingulina nodosaria* BERTHELIN, *1880*, Soc. géol. France, Mém., ser. 3, vol. 1, mem. 5, p. 64, pl. 4 (27), figs. 10a–c.
*Lingulina nodosaria* CHAPMAN, *1894*, Roy. Micr. Soc., Journ., pp. 153–154, pl. 3, figs. 1a–b.
*Lingulina nodosaria* EGGER, *1899*, Bayer. Akad. Wiss. München, Abh., Cl. II, vol. 21, p. 85, pl. 16, figs. 34–35; *1907*, Nat. Ver. Nassau, Bericht., XX, p. 27, pl. 8, fig. 26.
*Lingulina nodosaria* EICHENBERG, *1934*, Niedersächs geol. Ver. Jahresber., 26, p. 175, pl. 11, fig. 9; *1935*, Mitteil. Roemer-Mus., Folge 4, p. 24, pl. 2, fig. 12.

Test elongate, compressed, uniserial, rectilinear; chambers increasing in size as added, but not regularly; sutures distinct, depressed, curved; wall calcareous, smooth; aperture elongately oval. Length of hypotype, 0.64 mm; width, 0.165 mm; thickness, 0.11 mm.

*Type.*—Hypotype (Cushman Coll. no. 25058) from base of zone 1, Grayson Bluff.

### LINGULINA NODOSARIA SEMIORNATA Reuss
Plate 16, figures 21a–b

*Lingulina semiornata* REUSS, *1863*, Akad. Wiss. Wien., Sitz., vol. 46, p. 91, pl. 12, figs. 11a–b.
*Lingulina semiornata* CHAPMAN, *1894*, Roy. Micr. Soc., Journ., p. 653, pl. 3, figs. 2a–b, 3a–b.
*Lingulina semiornata* EGGER, *1899*, Bayer. Akad. Wiss. München, Abh., Cl. 2, vol. 21, p. 85, pl. 25, figs. 20–21.
*Lingulina semiornata* FRANKE, *1928*, Preuss. geol. Landesanstalt, Abh., n. ser., vol. 111, pp. 56–57, pl. 4, fig. 37.

Test elongate, rectilinear, slightly compressed; chambers rounded, increasing in height as added; sutures distinct, depressed, curved, convex upward; wall calcareous, smooth, except for very fine lengthwise striations which cross the chambers, being more prominant near the sutures and dying out toward the centers of the chambers; aperture elongate, terminal. Length of hypotype, 0.61 mm; width, 0.19 mm; thickness, 0.15 mm.

*Type.*—Hypotype (Cushman coll. no. 25059) from top of zone 2, Grayson Bluff.

*Remarks.*—This species is characterized by the fine striations and the oval cross-section. It is considered to be a variety of *L. nodosaria* Reuss because of its similar form and irregularly enlarging chambers. The variety differs in the presence of the fine striations, is somewhat thicker and has more inflated chambers. The fine striations may be easily overlooked as they are quite faint.

### LINGULINA SERRATA Tappan, n. sp.
Plate 16, figures 22a–b

Test elongate, uniserial, rectilinear, compressed; chambers increasing in height as added, edges of chambers overlapping and produced into distinct short spines, especially in the later chambers, chambers thickest centrally at the apertural end of each, thinner at the edges, becoming sub-carinate; sutures distinct, depressed; wall carcareous, smooth; aperture terminal, elongate. Length of holotype, 0.45 mm; width, 0.14 mm; thickness, 0.07 mm.

*Type.*—Holotype (Cushman coll. no. 25060) from lower part of zone 1, Grayson Bluff.

*Remarks.*—This species is similar to *L. denticulocarinata* Chapman, but differs in much more angular and produced chamber margins, less distinctly bulbous central portion as seen in cross section, and higher chambers in comparison to their width. The species is fairly common throughout the Grayson and is easily distinguished by the spines at the chamber margins.

## Genus VAGINULINA d'Orbigny, 1826

### VAGINULINA COMPLANATA (Reuss)
Plate 16, figures 23a–24

*Cristellaria complanata* REUSS, *1863*, Akad. Wiss. Wien., Sitz., vol. 46, p. 92, pl. 12, fig. 13.
*Cristellaria complanata* BERTHELIN, *1880*, Soc. géol. France, Mém., ser. 3, vol. 1, mem. 5, p. 54.
*Cristellaria complanata* CHAPMAN, *1894*, Roy. Micr. Soc., Journ., pp. 653–654, pl. 10, figs. 12a–b.
*Cristellaria complanata* EGGER, *1899*, Bayer. Akad. Wiss. München, Abh., Cl. 2, vol. 21, p. 114, pl. 11, figs. 29–30.

Test medium in size, compressed, slightly coiled, chambers increasing very little in height; sutures distinct, arcuate, slightly thickened, a little depressed; wall calcareous, smooth, an apical spine sometimes present, periphery with a keel; aperture radiate, at the peripheral angle. Length of hypotype of figure 23, 0.73 mm; breadth, 0.37 mm; width, 0.08 mm. Length of smaller specimen, including length of apical spine, 0.41 mm; breadth, 0.14 mm; length of apical spine, 0.045 mm.

*Types.*—Hypotype of figure 23 (Cushman coll. no. 25061) and figure 24 (Cushman coll. no. 25062), both from base of zone 1, Grayson Bluff.

*Remarks.*—This species has been recorded from England, France and Germany and is common in the Grayson formation of Texas.

### VAGINULINA COMPLANATA (Reuss) var. PERSTRIATA Tappan, n. var.
Plate 16, figure 25

Test medium in size, compressed, slightly coiled, chambers increasing very little in height; sutures distinct, slightly depressed, curved; wall calcareous, surface ornamented with about 16 low, distinct, obliquely parallel striations, outer margin with a keel; aperture radiate, at the peripheral angle. Length of holotype, 0.72 mm; breadth, 0.29 mm.

*Type.*—Holotype (Cushman coll. no. 25063) from middle of zone 1, Grayson Bluff.

*Remarks.*—*V. cristellarioides* Reuss differs from this form in possessing striations which parallel the test margins. Those of *V. complanata* (Reuss) var. *perstriata*, n. var. are oblique. It is common throughout the Grayson formation.

### VAGINULINA DEBILIS (Berthelin)
Plate 16, figures 26a–b

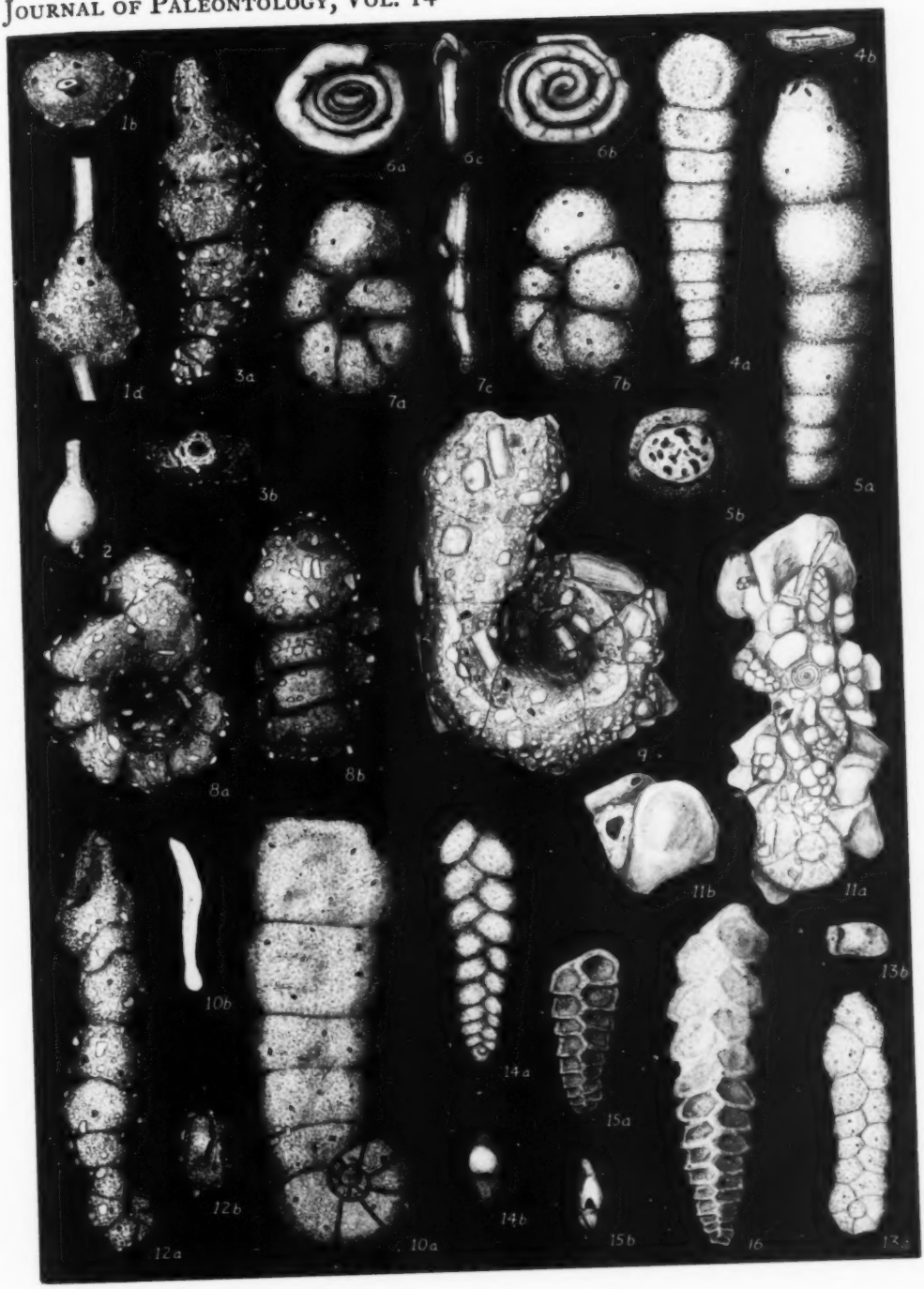
*Marginulina debilis* BERTHELIN, *1880*, Soc. géol. France, Mém., ser. 3, vol. 1, mem. 5, p. 35, pl. 3 (26), fig. 28.
*Marginulina debilis* CHAPMAN, *1894*, Roy. Micr. Soc., Journ., p. 161, pl. 4, fig. 15.
*Marginulina debilis* EGGER, *1910*, Nat. Ver. Regensburg, Bericht., p. 109, pl. 1, fig. 16.
*Dentalina debilis* EICHENBERG, *1933*, Niedersächs geol. Ver., Jahresber., 25, Folge 2, p. 183, pl. 23, fig. 10; *1934*, Niedersächs geol. Ver. Jahresber., 26, p. 167, pl. 12, fig. 9.

Test elongate, arcuate, slender, tapering, subtriangular in cross-section; chambers inflated, increasing in height as added, ventral side wide, margins angled, resulting in the triangular appearance; sutures distinct, depressed, highest at the dorsal margin; wall calcareous, surface smooth; aperture radiate at the dorsal angle, which is slightly produced and neck-like. Length of hypotype 1.07 mm; width, 0.11 mm; thickness, 0.09 mm.

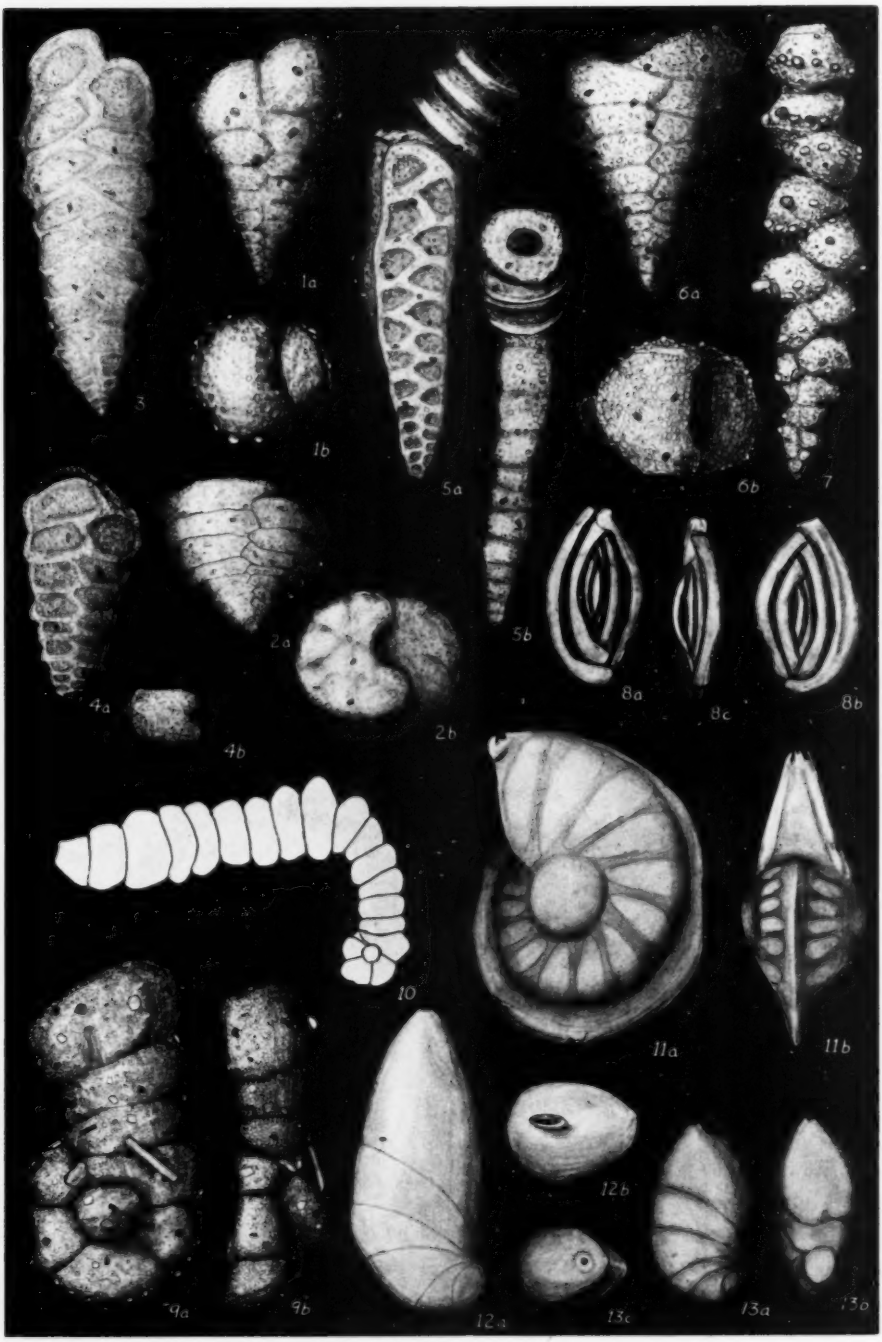
---

### EXPLANATION OF PLATE 14

FIGS. *1a–2—Lagenammina pyriformis* Tappan, n. sp. *1a*, Side view; *b*, apertural view of holotype; *2*, specimen showing eroded surface; ×55. (p. 94)
*3a–b—Reophax deckeri* Tappan, n. sp. *3a*, Side view; *b*, apertural view of holotype, ×44. (p. 94)
*4a–b—Reophax minuta* Tappan, n. sp. *4a*, Side view; *b*, apertural view of holotype, ×77. (p. 94)
*5a–b—Haplostiche texana* (Conrad). *5a*, Side view; *b*, apertural view, ×10. (p. 95)
*6a–c—Ammodiscus gaultinus* Berthelin. *6a*, *b*, Side views; *c*, edge view, ×44. (p. 95)
*7a–c—Haplophragmoides concava* (Chapman). *7a–b*, Side views; *c*, edge view, ×44. (p. 95)
*8a–9—Ammobaculites goodlandensis* Cushman and Alexander. *8a*, Side view; *b*, edge view of hypotype. ×44. *9*. Side view of specimen with more complete uniserial portion, ×77. (p. 96)
*10a–b—Ammobaculites cuyleri* Tappan, n. sp. *10a*, Side view of holotype; *b*, cross-section to show compressed form, ×44. (p. 96)
*11a–b—Ammobaculites testacea* Tappan, n. sp. *11a*, Side view of holotype; *b*, apertural view, ×77. (p. 96)
*12a–b—Ammobaculites variabilis* Tappan, n. sp. *12a*, Side view of holotype; *b*, apertural view, ×55. (p. 97)
*13a–b—Spiroplectammina ammovitrea* Tappan, n. sp. *13a*, Side view of holotype; *b*, apertural view, ×77 (p. 97)
*14a–b—Spiroplectammina longa* Lalicker. *14a*, Side view; *b*, apertural view, ×55. (p. 97)
*15a–16—Spiroplectammina nuda* Lalicker. *15a*, Side view; *b*, apertural view; *16*, Side view of an adult specimen, ×55. (p. 98)




Tappan, Cretaceous Foraminifera




Tappan, Cretaceous Foraminifera

*Type.*—Hypotype (Cushman coll. no. 25064) from middle of zone 1, Grayson Bluff.

*Remarks.*—This is a very slender and delicate form and complete tests are rare. It occurs throughout the Grayson formation and is easily distinguished by the subtriangular appearance.

### VAGINULINA GEISENDÖRFERI Franke
Plate 17, figures 1a–c

*Vaginulina geisendörferi* FRANKE, *1928*, Preuss. geol. Landes., Abh., n. ser., vol. 111, p. 80, pl. 7, figs. 18a–b.
*Vaginulina stutzeri* EICHENBERG, *1934*, 26 Niedersächs geol. Ver. Jahresber., 26, p. 176, pl. 14, fig. 1.

Test elongate, parallel-sided, rectilinear; chambers inflated, last chamber nearly as thick as the proloculum; apertural face convex and almost as wide as the sides, dorsal side narrower; sutures distinct, depressed, curved, highest at the dorsal side; wall calcareous, smooth, dorsal and ventral lateral angles carinate; aperture at the dorsal angle. Length of hypotype, 0.69 mm; width of side, 0.12 mm; breadth of ventral side, 0.19 mm; breadth of dorsal side, 0.07 mm.

*Type.*—Hypotype (Cushman coll. no. 25065) from base of zone 1, Grayson Bluff.

*Remarks.*—This species is most similar to *V. recta* Reuss, but differs in the wide, convex apertural face, the inflated and much shorter chambers and the depressed sutures. The species was first described from northern Germany. It is fairly common in the Grayson formation.

### VAGINULINA KOCHII Roemer
Plate 17, figures 2–4

*Vaginulina kochii* ROEMER, *1840–1841*, Verst. norddeutsch. Kreide, p. 96, pl. 15, fig. 10.
*Vaginulina arguta* REUSS, *1860*, Akad. Wiss. Wien., Sitz., vol. 40, p. 202, pl. 8, fig. 4; *1863*, Ibid., vol. 46, p. 47, pl. 3, fig. 13.
*Vaginulina truncata* REUSS, *1863*, Ibid., vol. 46, p. 47, pl. 3, fig. 9.
*Vaginulina truncata* BERTHELIN, *1880*, Soc. géol. France, Mém., ser. 3, vol. 1, mem. 5, p. 39, pl. 1 (24), figs. 25–28.
*Vaginulina arguta* BERTHELIN, *1880*, Ibid., p. 42, pl. 2, figs. 7a–c (8a–b).
*Vaginulina arguta* BURROWS, SHERBORN and BAILEY, *1890*, Roy. Micr. Soc., Journ., pt. 5, p. 559, pl. 10, figs. 14–15.
*Vaginulina truncata* CHAPMAN, *1894*, Roy. Micr. Soc., Jour., pp. 423–424, pl. 8, figs. 5–6.
*Vaginulina arguta* EGGER, *1899*, Bayer Akad. Wiss. München, Abh., Cl. 2, vol. 21, p. 99, pl. 10, fig. 10.
*Vaginulina truncata* EGGER, *1899*, Ibid., p. 99, pl. 25, figs. 14–15; *1907*, Nat. Ver. Nassau, Bericht., XX, pp. 32–33, pl. 3, fig. 17.
*Vaginulina arguta* FRANKE, *1928*, Preuss. geol. Landes., Abh., n. ser., vol. 111, pp. 78, 83, pl. 7, fig. 29.
*Vaginulina kochii* CUSHMAN and ALEXANDER, *1930*, Cushman Lab. Foram. Research, Contr., vol. 6, no. 1, p. 1, pl. 1, figs. 1–9.
*Vaginulina arguta* EICHENBERG, *1933*, Niedersächs geol. Ver., Jahresber., 25, Folge 1, p. 10, pl. 8, fig. 5.
*Vaginulina truncata* EICHENBERG, *1933*, Ibid., p. 187, pl. 20, fig. 6; 1934, Ibid., p. 179, pl. 16, fig. 5; 1935, Mitteil, Roemer-Mus., No. 37, p. 28, pl. 5, fig. 9.

The following description is from Cushman and Alexander (1930):

Test much compressed, the sides parallel, sutures raised, wall otherwise typically smooth, periphery usually somewhat concave; aperture at the upper angle of the test, radiate.

---

### EXPLANATION OF PLATE 15

FIGS. *1a–2b—Textularia rioensis* Carsey. *1a*, Side view of typical specimen; *b*, apertural view; *2a*, side view of short, compressed specimen of the type called *T. conica* by Carsey; *b*, apertural view, ×55. (p. 98)
*3–4b—Textularia washitensis* Carsey. *3*, Side view of adult specimen, ×44; *4a*, side view; *b*, apertural view of shorter form, ×55. (p. 98)
*5a–b—Bigenerina wintoni* Cushman and Alexander. *5a*, Side view; *b*, edge view of hypotype, ×44. (p. 99)
*6a–b—Gaudryina cushmani* Tappan, n. sp. *6a*, Side view; *b*, apertural view of holotype, ×44. (p. 99)
*7—Gaudryinella delrioensis* Plummer. Side view, ×77. (p. 99)
*8a–c—Massilina planoconvexa* Tappan, n. sp. *8a*, *b*, Side views of holotype; *c*, edge view, ×44. (p. 100)
*9a–10—Placopsilina longa* Tappan, n. sp. *9a*, Side view; *b*, edge view of holotype, ×44; *10*, outline drawing of unusually long specimen, ×12. (p. 100)
*11a–b—Lenticulina gaultina* (Berthelin). *11a*, Side view; *b*, face view, ×44. (p. 101)
*12a–b—Marginulina* sp. A. *12a*, Side view; *b*, apertural view, ×77. (p. 101)
*13a–c—Marginulina* sp. B. *13a*, Side view; *b*, face view; *c*, apertural view, ×55. (p. 101)

Length of small microspheric specimen, 0.39 mm; width, 0.19 mm; length of large megalospheric form, 1.96 mm; width, 0.36 mm.

*Types.*—Hypotype of figure 2 (Cushman coll. no. 25066) and figure 3 (Cushman coll. no. 25067) from middle of zone 1. Hypotype of figure 4 (Cushman coll. no. 25068) from base of zone 1, Grayson Bluff.

*Remarks.*—According to Cushman and Alexander (1930 a),

> The whole test is generally triangular in side view but the outline varies greatly. . . . In the microspheric form the dorsal margin may be nearly straight, and the early chambers show very little of the curve, the whole test being less broad than in the microspheric form.
>
> Roemer's species is apparently the same as that figured later by Reuss, Berthelin and others from the Lower Cretaceous of Europe. The raised sutures and concave or flattened periphery remain constant while the shape changes as noted.

*V. kochii* Roemer was recorded by Cushman from the Duck Creek formation. It ranges throughout the Washita group and is common throughout the Grayson formation.

### VAGINULINA KOCHII STRIOLATA Reuss
Plate 17, figure 5

*Vaginulina striolata* REUSS, *1863*, Akad. Wiss. Wien., Sitz., vol. 46, pt. 1, p. 46, pl. 3, fig. 7.
*Vaginulina strombecki* REUSS, *1863*, Ibid., p. 46, pl. 3, fig. 8.
*Vaginulina comitina* BERTHELIN, *1880*, Soc. géol. France, Mém., ser. 3, vol. 1, mem. 5, p. 38, pl. 1, figs. 21a–d.
*Vaginulina gaultina* BERTHELIN, *1880*, Ibid., p. 39, pl. 1, figs. 23–24.
*Vaginulina gaultina* CHAPMAN, *1894*, Roy. Micr. Soc., Jour., p. 425, pl. 8, figs. 8a–b.
*Vaginulina comitina* CHAPMAN, *1894*, Ibid., p. 426, pl. 8, fig. 11.
*Vaginulina striolata* CHAPMAN, *1894*, Ibid., p. 425, pl. 8, fig. 10.
*Vaginulina striolata* FRANKE, *1928*, Preuss. geol. Landesansalt, Abh., n. ser., vol. 111, pp. 78, 82, pl. 7, fig. 23.
*Vaginulina kochii* var. *striolata* CUSHMAN and ALEXANDER, *1930*, Cushman Lab. Foram. Research, Contr., vol. 6, pt. 1, p. 4, pl. 1, figs 10–16; Cushman, *1933*, Spec. Publ. 5, pl. 20, fig. 11.
*Vaginulina* sp. EICHENBERG, *1934*, Niedersächs geol. Ver., Jahresber., 26, p. 177, pl. 14, fig. 6.

The following description is from Cushman and Alexander (1930):

> In this variety the raised sutures are usually marked by obliquely transverse depressions, breaking the sutures into a series of short oblique ridges. This ornamentation may be very slight or may increase and spread somewhat to the intermediate chamber portions as well as the sutures. Occasionally only a few of the sutures show the ornamentation, and in other specimens in the same series it may involve nearly the whole surface.

Length of hypotype, 1.16 mm; width, 0.27 mm.

*Type.*—Hypotype (Cushman coll. no. 25069) from base of zone 1, Grayson Bluff.

*Remarks.*—Cushman lists this variety from the Duck Creek formation. It ranges throughout the Washita group and is common in the Grayson formation.

### VAGINULINA LINEARIS (Reuss)
Plate 17, figures 6a–b

*Cristellaria linearis* REUSS, *1863*, Akad. Wiss. Wien., Sitz., vol. 46, p. 66, pl. 12, figs. 1a–b.
*Cristellaria linearis* CHAPMAN, *1894*, Roy. Micr. Soc., Journ., pp. 645–646, pl. 9, figs. 1a–b.

Test elongate, slender, arcuate, early stage but faintly suggestive of a coil, subtriangular in cross-section, sharply angled dorsal margin; chambers somewhat inflated; sutures distinct, depressed, curved, highest dorsally; wall calcareous, surface smooth; aperture radiate, at the peripheral angle. Length of hypotype, 0.56 mm; breadth, 0.09 mm; width, 0.06 mm.

*Type.*—Hypotype (Cushman coll. no. 25070) from middle of zone 1, Grayson Bluff.

*Remarks.*—This species has been recorded from England and Germany and is fairly common in the Grayson formation. *V. parallela* (Reuss) = *Cristellaria parallela* Reuss (1863 a) may be the megalospheric form of *V. linearis* (Reuss), as the two are very similar.

### VAGINULINA RECTA Reuss
Plate 17, figures 7a–8

*Vaginulina recta* REUSS, *1863*, Akad. Wiss. Wien., Sitz., vol. 46, p. 48, pl. 3, figs. 14–15.
*Vaginulina recta* BERTHELIN, *1880*, Soc. géol. France, Mém., Ser. 3, vol. 1, mem. 5, p. 41, pl. 25, figs. 5a–b, 6a–b.
*Vaginulina recta* BURROWS, SHERBORN and BAILEY, *1890*, Roy. Micr. Soc., Journ., pt. 5, p. 559, pl. 10, figs. 10–13.
*Vaginulina recta* CHAPMAN, *1894*, Roy. Micr. Soc., Journ., p. 422, pl. 8, fig. 1.
*Vaginulina recta* EGGER, *1907*, Nat. Ver. Nassau, Ber., 20, p. 32, pl. 3, figs. 21–22; *1910*, Nat. Ver. Regensburg., Bericht., pp. 112–113, pl. 1, fig. 6.

*Vaginulina recta* FRANKE, *1928*, Preuss. geol. Landes., Abh., n. ser., vol. 111, p. 82, pl. 7, figs. 27–28.
*Vaginulina recta* CUSHMAN and ALEXANDER, *1930*, Cushman Lab. Foram. Research, Contr., vol. 6, pt. 1, p. 4, pl. 1, figs. 17–22

The following description is from Cushman and Alexander (1930):

Test elongate, much compressed, the faces nearly parallel, periphery usually slightly concave, chambers of nearly uniform width throughout, giving a test with nearly parallel sides; sutures raised, test otherwise smooth; aperture at the dorsal angle, radiate.

Length of large hypotype, 0.98 mm; width, 0.08 mm; width of proloculum, 0.17 mm; thickness through proloculum, 0.19 mm.

*Types.*—Adult hypotype (Cushman coll. no. 25071) from base of zone 1, hypotype showing plastogamy (Cushman coll. no. 25072) from middle of zone 1, Grayson Bluff.

*Remarks.*—According to Cushman and Alexander (1930),

This species is widely recorded in the Cretaceous of Europe by Reuss, Berthelin, Burrows, Sherborn and Bailey, Chapman, Egger, and Franke. It is close to *V. kochii* in many of its characters, but may be distinguished by the narrow test with nearly parallel sides.

The proloculum varies from smooth to a form with two or more striations across it. Cushman and Alexander recorded this species from the Denton and Weno formations. It ranges throughout the Washita group, but is less common than *V. kochii* in the Grayson.

VAGINULINA TRIPLEURA (Reuss)
Plate 17, figures 11a–12b

*Cristellaria tripleura* REUSS, *1860*, Akad. Wiss. Wien., Sitz., vol. 40, p. 211, pl. 9, fig. 5.
*Cristellaria tripleura* CHAPMAN, *1894*, Roy. Micr. Soc., Jour., p. 652, pl. 10, figs. 6a–b.
*Cristellaria tripleura* EGGER, *1899*, Bayer Akad. Wiss. München, Abh., Cl. 2, vol. 21, p. 112, pl. 12, figs. 22–24.

Test small, broad, arcuate; chambers inflated; sutures distinct, depressed, curved to slightly sigmoid; wall calcareous, smooth, aperture radiate, at the peripheral angle. Length of specimen in figure 11, 0.47 mm; width, 0.16 mm; length of specimen in figure 12, 0.35 mm; width, 0.13 mm.

*Types.*—Hypotypes in figure 11 (Cushman coll. no. 25075) and figure 12 (Cushman coll. no. 25076) from middle of zone 1, Grayson Bluff.

*Remarks.*—This species tends somewhat toward the form of *Saracenaria*. It is fairly common in the Grayson formation.

Genus FRONDICULARIA Defrance, 1826
FRONDICULARIA sp.
Plate 17, figures 13a–14

Test short and narrow, chambers slightly inflated, but never as thick as the proloculum; sutures distinct, depressed, highly arched in an acute angle; wall calcareous, nearly smooth, with about five or six very faint, closely parallel, vertical ribs crossing the adult chambers and two or more stronger vertical ribs crossing the proloculum and early one or two chambers, a few short, fine and oblique additional ribs bound the central strong ribs of the proloculum; aperture radiate, terminal, on a short neck. Young specimen in figure 13 has a length of 0.48 mm; breadth, 0.21 mm; width through proloculum, 0.12 mm, greatest width through chambers, 0.075 mm. The length of the adult fragment, the early part of which is missing, is 0.66 mm, and the breadth is 0.28 mm.

*Type.*—Adult specimen (Cushman coll. no. 25078) and young specimen (Cushman coll. no. 25077) are both from the base of zone 1, Grayson Bluff.

*Remarks.*—This species is similar to *F. decheni* Reuss but differs in the less distinct ribs, the more prominant central pair of ribs, and the lobulate periphery. *F. decheni* is of equal breadth throughout its length. This is the only species of *Frondicularia* thus far found in the Grayson formation. Generally only the young forms with one or two chambers occur and the adult fragment illustrated was the only adult specimen found by the writer. This is especially noteworthy in view of the great development of *Frondicularia*, *Flabellina* and *Kyphopyxa* in the Texas Cretaceous. The young forms of this species occur sparingly throughout the Grayson formation.

Subfamily LAGENINAE
Genus LAGENA Walker and Jacob, 1798
LAGENA APICULATA (Reuss)
Plate 17, figures 15a–b

*Oolina apiculata* REUSS, *1850*, Haidinger's Nat. Abh., vol. 4, p. 22, pl. 1, fig. 1.
*Lagena apiculata* REUSS, *1863*, Akad. Wiss.

Wien., Sitz., vol. 46, pp. 318–319, pl. 1, figs. 4–8, 10–11.

*Lagena apiculata* CHAPMAN, *1893*, Roy. Micr. Soc., Jour., p. 581, pl. 8, figs 2a–3b.

*Lagena apiculata* EGGER, *1899*, Bayer. Akad. Wiss. München, Abh., Cl. 2, vol. 21, p. 103, pl. 5, fig. 32; *1907*, Nat. Ver. Nassau, Ber., 20, p. 34, pl. 5, fig. 17; 1910, Nat. Ver. Regensburg, Bericht., p. 103, pl. 1, fig. 24.

*Lagena apiculata* FRANKE, *1928*, Preuss. geol. Landesanstalt, Abh., n. ser., vol. 111, pp. 84, 86, pl. 7, fig. 86.

*Lagena apiculata* EICHENBERG, *1934*, Niedersächs geol. Ver., Jahresber., 26, p. 182, pl. 12, fig. 12.

Test tiny, unilocular, ovate, widest toward the base, apical spine at base; wall calcareous, surface smooth; aperture radiate, on a short neck. Length of figured specimen, 0.28 mm; width, 0.17 mm.

*Type.*—Hypotype (Cushman coll. no. 25079) from base of zone 1, Grayson Bluff.

*Remarks.*—This species has been recorded from strata varying in age from Cretaceous to Recent. It is fairly common in the Grayson formation and ranges throughout the Washita group. Only a limited synonymy is given here.

### LAGENA HISPIDA Reuss var.
Plate 17, figures 16a–b

*Lagena hispida* REUSS, *1858*, Deutsche geol. Gesell., Zeitschr., vol. 10, p. 434.

*Lagena hispida* CHAPMAN, *1893*, Roy. Micr. Soc., Jour., pp. 582–583, pl. 8, figs. 9a–10b.

*Lagena hispida* EICHENBERG, *1934*, 26 Niedersächs geol. Ver., Jahresber., 26, p. 182, pl. 17, fig. 10.

Test small, unilocular, subspherical; wall calcareous, surface finely hispid, covered with numerous, microscopically fine and numerous spines; somewhat longer apical spine at the base; aperture simple, terminal, at the end of a long neck, which is nearly one-third of the length of the entire test. Length of hypotype, including neck, 0.355 mm; length of neck, 0.095 mm; diameter of chamber, 0.24 mm.

*Type.*—Hypotype (Cushman coll. no. 25080) from top of zone 2, Grayson Bluff.

*Remarks.*—This species is probably a variety of that described by Reuss and later recorded from strata varying in age from Cretaceous to Recent. The surficial spines are much finer and more numerous than those covering the test of the Upper Cretaceous form identified as *L. hispida* Reuss. This species occurs throughout the Grayson formation.

### LAGENA LEPTATA Tappan, n. sp.
Plate 17, figure 17

Test unilocular, cylindrically elongate, sides nearly parallel; wall calcareous, surface ornamented with 12 to 14 low, narrow ribs which twist slightly upon the surface of the test; aperture simple, terminal at the end of a short neck. Length of holotype, 0.37 mm; diameter, 0.10 mm; length of neck, 0.04 mm.

*Type.*—Holotype (Cushman coll. no. 25081) from middle of zone 2, Grayson Bluff. This species occurs in varying abundance throughout the Grayson formation.

*Remarks.*—This species differs from *L. sulcata* (Walker and Jacob) in the narrower twisting ribs with relatively flat interspaces, and the elongate and cylindrical form.

### LAGENA STRIATIFERA Tappan, n. sp.
Plate 17, figures 18a–b

Test small, unilocular, globose, wall calcareous, surface ornamented with about 28 fine, low ribs; aperture simple, terminal, at the end of a short neck. Length of holotype, 0.25 mm; diameter, 0.16 mm; length of neck, 0.05 mm.

*Type.*—Holotype (Cushman coll. no. 25082) from upper part of zone 1, Grayson Bluff.

*Remarks.*—This species differs from *L. sulcata* (Walker and Jacob), which also occurs in the Grayson, in its globular shape and much finer and more numerous costae. It is fairly common in the Grayson, although at first glance it is easily confused with *L. sulcata*.

### LAGENA SULCATA (Walker and Jacob)
Plate 17, figures 19a–b

*Serpula* (*Lagena*) *sulcata* WALKER and JACOB, *1798*, Adam's Essays, Kannmacher's edition, p. 634, pl. 14, fig. 5.

*Lagena sulcata* CARSEY, *1926*, Texas Univ. Bull. 2612, p. 31, pl. 7, fig. 4.

*Lagena sulcata* PLUMMER, *1931*, Texas Univ. Bull. 3101, p. 159, pl. 10, fig. 11.

The following description is from Plummer (1931 b):

Test flask-shaped, body somewhat elongate and ornamented by 10 to 12 sharp costae that merge anteriorly and posteriorly into the curvature of the test; aperture radiate at the end of a long neck; apical spine missing on all specimens observed but broken stump proves its original existence.

Length of hypotype, 0.23 mm; diameter, 0.15 mm; length of neck, 0.04 mm.

*Type.*—Hypotype (Cushman coll. no. 25083) from base of zone 3, Grayson Bluff.

*Remarks.*—This species has been recorded from Cretaceous to Recent. Only a very limited synonymy is given here. This species is common both in the Del Rio and the Grayson and ranges throughout the Washita group.

Family POLYMORPHINIDAE
Subfamily POLYMORPHININAE
Genus PALEOPOLYMORPHINA Cushman and Ozawa, 1930
PALEOPOLYMORPHINA OZAWAI
Tappan, n. sp.
Plate 17, figures 20a–21c

Test elongate, early chambers spiral, later ones biserial, chambers inflated, elongate, last two chambers much enlarged, overhanging over earlier chambers; sutures distinct, depressed; wall calcareous, surface smooth; aperture radiate, terminal on the last formed chamber. Length of holotype, 0.38 mm; breadth, 0.15 mm; length of smaller specimen, 0.32 mm; breadth, 0.16 mm.

*Type.*—Holotype (Cushman coll. no. 25084) and paratype (Cushman coll. no. 25085) from lower part of zone 1, Grayson Bluff.

*Remarks.*—This species differs from *P. gaultina* (Berthelin) in the irregular margin caused by the more inflated chambers and more deeply depressed sutures. *P. ozawai*, n. sp. is also one-sixth to one-third larger than *P. gaultina*. The species is named in honor of the late Dr. Yoshiaki Ozawa, who contributed much to the study of this family.

Genus PSEUDOPOLYMORPHINA Cushman and Ozawa, 1928
PSEUDOPOLYMORPHINA ROANOKENSIS
Tappan, n. sp.
Plate 17, figures 22a–23, 25

Test elongate; early portion somewhat irregular, globuline or quinqueloculine at first, later tending to become uniserial; sutures indistinct; wall calcareous, surface of early portion smooth, later portion of test and apertural fistulose growth finely hispid; aperture obscured by fistulose growth, no unbroken specimens without it having been observed, fistulose portion consisting of long, irregular, tapering tubes of various sizes, frequently broken off so that they may be mistaken for a species of *Ramulina*. Total length of holotype, 0.49 mm; length from tip to tip of fistulose portion, 0.635 mm; maximum diameter of test, 0.13 mm.

*Type.*—Holotype (Cushman coll. no. 25086) from lower part of zone 1, paratypes (Cushman coll. no. 25087 and Cushman coll. no. 25088) from middle of zone 1, Grayson Bluff.

*Remarks.*—The specific name refers to the type locality of the species, which is near Roanoke, Denton County, Texas. *P. roanokensis* is fairly common at this locality. The early portion is somewhat similar to *P. jonesi* Cushman and Ozawa (1930, p. 107) in general outline, appearance of the sutures, and cylindrical form. *P. roanokensis* differs in the more tapering base, hispid surface near the aperture, typical fistulose growth and smaller size.

Genus GLOBULINA d'Orbigny, 1839
GLOBULINA LACRIMA Reuss var.
SUBSPHERICA (Berthelin)
Plate 17, figures 24a–b

*Polymorphina subspherica* BERTHELIN, *1880*, Soc. Géol. France, Ser. 3, vol. 1, mem. 5, p. 58, pl. 4, figs. 18a–b.
*Globulina lacrima* var. *subspherica* CUSHMAN and OZAWA, *1930*, U. S. Nat. Mus. Proc. vol. 77, art. 6, p. 78, pl. 19, figs. 5–7.

The following description of *Globulina lacrima* Reuss is from Cushman and Ozawa (1930):

Test subglobular, the base broadly rounded, apertural end produced and regularly acuminate, the sides straight and not concave, typically rounded in end view; chambers few, extending back almost to the base; sutures not depressed; wall smooth; aperture radiate, slightly produced.

According to Cushman and Ozawa (1930) the variety differs from the typical form

in the slightly compressed test, which is more rounded at the base than at the apertural end. . . . Length, 0.33–0.45 mm; breadth, 0.30–0.40 mm; thickness, 0.20–0.30 mm.

Length of hypotype, including fistulose growth, 0.35 mm; width, 0.16 mm.

*Type.*—Hypotype (Cushman coll. no. 25089) from middle of zone 1, Grayson Bluff.

*Remarks.*—The majority of the Grayson

specimens are fistulose. This variety is fairly common in the Grayson formation.

Genus PYRULINA d'Orbigny, 1839
PYRULINA CYLINDROIDES (Roemer)
Plate 18, figures 1a–c

*Polymorphina cylindroides* ROEMER, *1838*, Neues Jahrb., p. 385, pl. 3, fig. 26.
*Polymorphina cylindroides* H. B. BRADY, PARKER and JONES, *1870*, Linn. Soc., Trans., vol. 27, p. 221, pl. 39, figs. 6a–c.
*Polymorphina fusiformis* CUSHMAN (not ROEMER), *1926*, Amer. Assoc. Petroleum Geologist, Bull., vol. 10, p. 604, pl. 20, fig. 14.
*Pyrulina cylindroides* CUSHMAN and OZAWA, *1930*, U. S. Nat. Mus. Proc., vol. 77, art 6, p. 56, pl. 14, figs. 1–5.

The following description is from Cushman and Ozawa (1930):

Test elongate, fusiform to cylindrical, acuminate toward both extremities, almost circular in cross-section; chambers elongate, not much embracing, arranged in a nearly triserial series, tending to become biserial, each succeeding chamber farther removed from the base; sutures but little depressed; wall smooth; aperture radiate. Length, 0.50 mm–1.10 mm; breadth, 0.18–0.32 mm; thickness, 0.15–0.30 mm.

*Type.*—Hypotype (Cushman coll. no. 25090) from middle of zone 1, Grayson Bluff.

*Remarks.*—The figured specimen, although somewhat smaller than the limits given by Cushman and Ozawa for this species, is nevertheless assigned to it. The length of the hypotype is 0.315 mm; breadth, 0.14 mm; width, 0.11 mm. This species is fairly common throughout the Grayson formation.

PYRULINA LONGA Tappan, n. sp.
Plate 18, figures 2a–b

Test large, elongate, fusiform, early chambers indistinct, probably triloculine, later biserial, tending to become uniserial, chambers elongate; sutures faint, very slightly depressed; wall calcareous, surface smooth; aperture generally obscured by a fistulose growth which has openings at the ends of the tubes. Length of holotype 0.92 mm; breadth, 0.27 mm.

*Type.*—Holotype (Cushman coll. no. 25091) from upper part of zone 2, Grayson Bluff.

*Remarks.*—*P. longa*, n. sp., resembles *P. fusiformis* (Roemer) in the general appearance, but is more slender in proportion to its length, the chambers are more elongate and the sutures more depressed. *P. longa*, n. sp. is an unusually large species and generally possesses the fistulose growth. It is fairly common in the Grayson formation.

Subfamily RAMULININAE
Genus RAMULINA Rupert Jones, 1875
RAMULINA cf. GLOBULIFERA Brady
Plate 18, figure 3

*Ramulina globulifera* BRADY, *1884*, Rept. Voy. Challenger, Zoology, vol. 9, p. 587, pl. 76, figs. 22–28
*Ramulina globulifera* CHAPMAN, *1896*, Roy. Micr. Soc., Jour., pp. 582–583, pl. 12, figs. 5–6.

This smooth, fistulose, branching, degenerate end member is referred to Brady's species by reason of its simplicity. Fistulose growths are also commonly developed about the apertures of the Grayson Polymorphinidae.

*Type.*—Hypotype (Cushman coll. no. 25092) from base of zone 1, Grayson Bluff.

RAMULINA sp.
Plate 18, figure 4

*Ramulina globulifera* CHAPMAN, *1896* (BRADY ?), Roy. Micr. Soc., Jour., pp. 582–583, pl. 12, figs. 3–4.

Test medium in size, generally composed of a single, elongate, fusiform, slightly arcuate chamber, open at both ends and roundly inflated near the mid-region; wall calcareous, surface distinctly hispid. Length of chamber, 0.80 mm; greatest width, 0.23 mm.

*Type.*—Figured specimen (Cushman coll. no. 25093) from top of zone 2, Grayson Bluff. This species is fairly common throughout the Grayson formation and has been separated from the typical *R. globulifera* Brady as it seems distinct.

Genus BULLOPORA Quenstedt, 1856
BULLOPORA CERVICORNIS (Chapman)
Plate 18, figure 5

*Ramulina cervicornis* CHAPMAN, *1896*, Roy. Micr. Soc. Jour., pp. 584–585, pl. 12, figs. 10–11.
*Vitriwebbina cervicornis* EICHENBERG, *1934*, Niedersächs geol. Ver., Jahresber., 26, p. 184, pl. 16, fig. 2.

Test an elongate attached tube, bifurcating occasionally, of nearly equal width throughout its length, the specimen figured

by Chapman showing a dichotomous arrangement of the branching; wall calcareous, surface smooth; apertures at the open ends of the tubes. Diameter of tube, 0.25 mm.

*Type.*—Hypotype (Cushman coll. no. 25094) from base of zone 1, Grayson Bluff.

*Remarks.*—Attached forms are common throughout the Grayson formation, but are probably generally overlooked as they are found adhering to shells of various macroscopic fossils.

BULLOPORA LAEVIS (Sollas)
Plate 18, figure 6

*Vitriwebbina laevis* SOLLAS, *1877*, Geol. Mag., n. ser., decade 2, vol. 4, no. 3, pp. 103–104, pl. 6, figs. 1–3.
*Vitriwebbina laevis* CHAPMAN, *1896*, Roy. Micr. Soc., Jour., pp. 585–586, pl. 12, fig. 12.

Test attached, consisting of a series of inflated oval chambers, connected by slender tubular necks, occasionally possessing a raised central bulb; aperture at the end of the stoloniferous necks. Length of figured specimen, 1.5 mm; breadth, 0.45 mm.

*Type.*—Hypotype (Cushman coll. no. 25095) from base of zone 1, Grayson Bluff.

BULLOPORA SP.
Plate 18, figure 7

Test attached, irregular in shape with numerous tubes arising from the central portion, an occasional chamber has raised central bulbs, similar to those of *B. laevis* (Sollas) and *B. cervicornis* (Chapman), to one of which it may later be referred. Total length of figured specimen, 1.95 mm; width varies from 0.16 to 0.35 mm.

*Type.*—Figured specimen (Cushman coll. no. 25094) from base of zone 1, Grayson Bluff. This form is on the lower left of the same shell fragment as the *B. cervicornis* hypotype.

Family HETEROHELICIDAE
Subfamily GÜMBELININAE
Genus GÜMBELINA Egger, 1899
GÜMBELINA WASHITENSIS Tappan, n. sp.
Plate 19, figures 1a–b

Test tiny, biserial, tapering gradually; chambers globular, closely appressed; sutures distinct, depressed, more angular toward the base, nearly straight among the later chambers; wall calcareous, finely perforate, surface smooth; aperture low, semilunate, at the base of the last formed chamber. Length of holotype, 0.21 mm; breadth, 0.12 mm; thickness, 0.08 mm.

*Type.*—Holotype (Cushman coll. no. 25096) from upper part of zone 1, Grayson Bluff.

*Remarks.*—This species differs from *G. globulosa* (Ehrenberg) in its much smaller size, being about one-half the size of the average Upper Cretaceous specimen, and usually much thinner. *G. washitensis* n. sp. is also very similar to *G. moremani* Cushman but is smaller, has more nearly horizontal sutures and more globular chambers. The chambers of *G. moremani* are somewhat produced at the lower margins, giving the chambers an obliquely elongate appearance. The sutures also are oblique. *G. washitensis* n. sp. is abundant in the Grayson formation and ranges throughout the Washita group.

Genus GÜMBELITRIA Cushman, 1933
GÜMBELITRIA HARRISI Tappan, n. sp.
Plate 19, figures 2a–b

Test minute, triserial, tapering rapidly; chambers becoming more inflated and more globular as added; sutures distinct, depressed; wall calcareous, finely perforate; aperture low, at the base of the last formed chamber. Length of holotype, 0.25 mm; width, 0.14 to 0.18 mm.

*Type.*—Holotype (Cushman coll. no. 25097) from middle of zone 1, Grayson Bluff.

*Remarks.*—This species differs from *G. cretacea* Cushman, of the Upper Cretaceous, in its larger size, lower aperture, less rapid flaring and comparatively less breadth. The species is abundant throughout the Grayson formation. It is named for Professor R. W. Harris, of the University of Oklahoma, to whom the author is indebted for valuable assistance in the preparation of this paper.

Genus GÜMBELITRIELLA Tappan, n. gen.

Genotype: *Gümbelitriella graysonensis* Tappan, n. sp.

Test free, small, triserial in the early stage, similar to *Gümbelitria*, later becoming multiserial at the top; chambers globular, increasing rapidly in size; sutures distinct, depressed; wall calcareous, finely perforate; aperture at base of final chamber. This

genus represents a stage of final multilocular development of the tiny triserial genus *Gümbelitria* as the genus *Pseudotextularia* represents a parallel stage of final multilocular development of the biserial genus *Gümbelina*.

*Range*—Lower Cretaceous.

GÜMBELITRIELLA GRAYSONENSIS
Tappan, n. sp.
Plate 19, figures 3a–c

Test small, free in the early stage similar to *Gümbelitria harrisi*, n. sp., later chambers added irregularly, generally with four or five exposed when viewed from above; chambers globular, increasing rapidly in size; sutures distinct, depressed; wall calcareous, smooth; aperture at base of last-formed chamber, occasionally more than one. Length of holotype. 0.26 mm; width across top, 0.18 to 0.22 mm.

*Type*—Holotype (Cushman coll. no. 25098) from upper part of zone 2, Grayson Bluff.

*Remarks.*—This species occurs throughout the Grayson formation, but has not been noted elsewhere to the knowledge of the author.

Family BULIMINIDAE
Subfamily BULIMININAE
Genus BULIMINA d'Orbigny, 1826
BULIMINA NANNINA Tappan, n. sp.
Plate 19, figures 4a–b

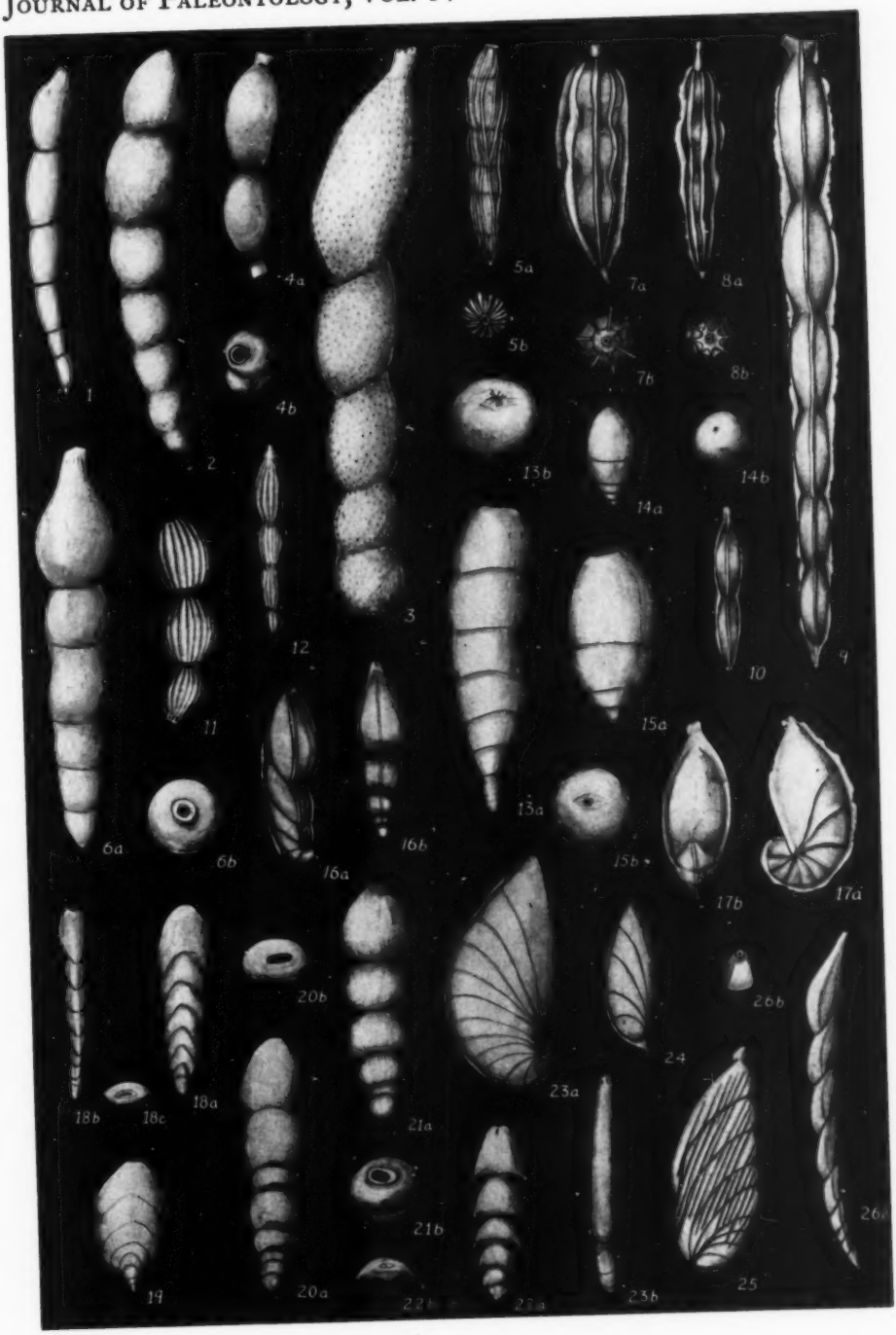
Test minute, triserial, chambers inflated, last series much larger than the earlier chambers, final pair of chambers forming one-half the test; sutures distinct, depressed; wall calcareous, smooth; aperture loop-shaped, in the face of the last formed chamber. Length of holotype, 0.21 mm; breadth, 0.14 mm.

*Type.*—Holotype (Cushman coll. no. 25099) from lower part of zone 1, Grayson Bluff.

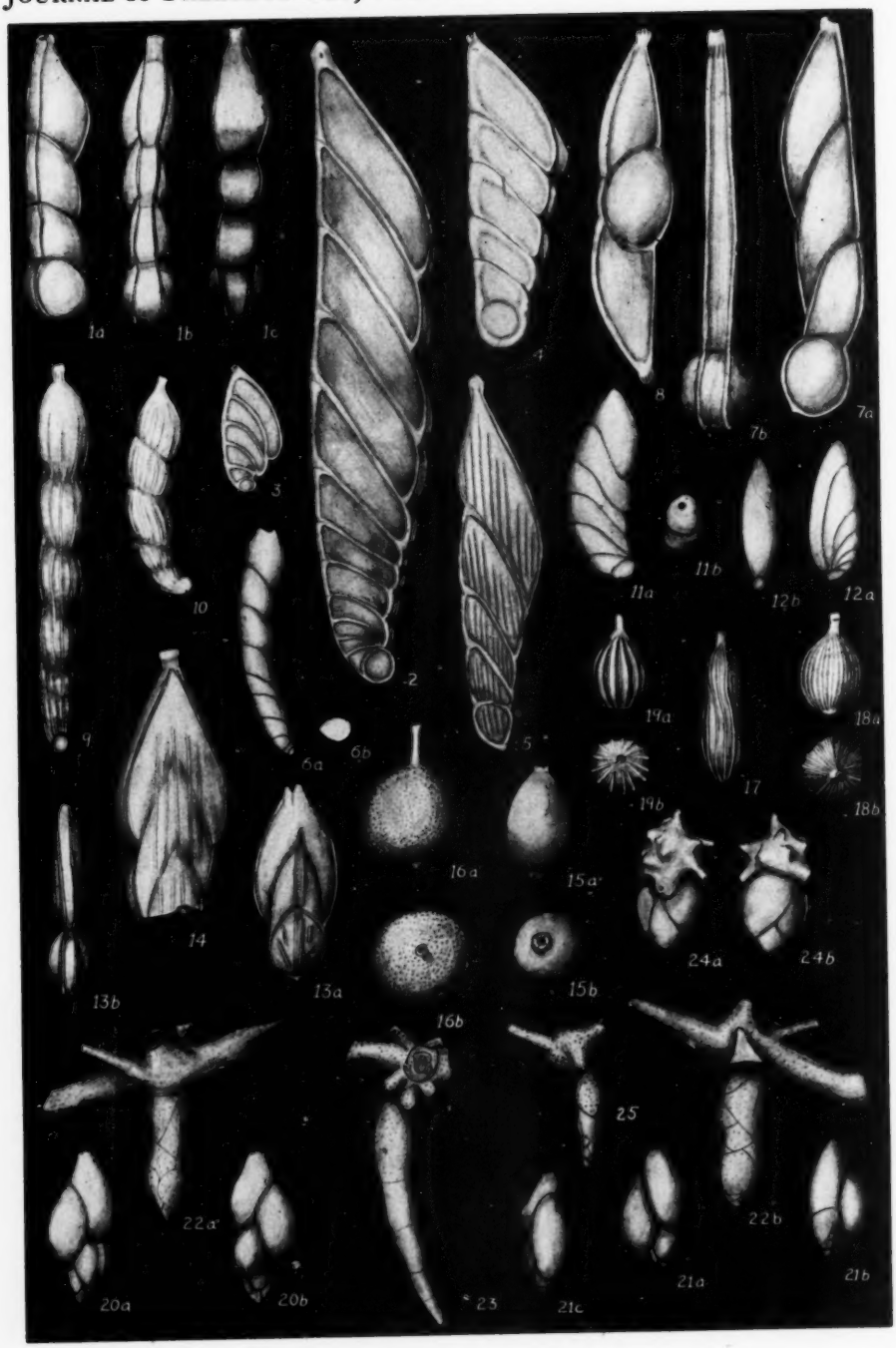
*Remarks.*—*Bulimina nannina* is somewhat similar to *B. ovula* Reuss, of Bohemia, but differs in its smaller size and lower last

EXPLANATION OF PLATE 16

FIGS. *1*—*Dentalina communis* (d'Orbigny). Side view, ×44. (p. 102)
*2*—*Dentalina cylindroides* Reuss. Side view, ×44. (p. 102)
*3*—*Dentalina hammensis* (Franke). Side view, ×77. (p. 102)
*4a–b*—*Dentalina* sp. *4a*, Side view of fragment; *b*, apertural view, ×55. (p. 102)
*5a–b*—*Nodosaria bifurcata* Tappan, n. sp. *5a*, Side view; *b*, apertural view of holotype, ×55. (p. 103)
*6a–b*—*Nodosaria lepida* Reuss. *6a*, Side view; *b*, apertural view, ×77. (p. 104)
*7a–8b*—*Nodosaria obscura* Reuss. *7a*, Side view; *b*, apertural view; *8a*, side view of another specimen; *b*, apertural view, ×44. (p. 104)
*9–10*—*Nodosaria chapmani* Tappan, n. sp. *9*, Holotype; *10*, paratype, showing neck and aperture, ×44. (p. 103)
*11*—*Nodosaria paupercula* Reuss. Side view, ×55. (p. 104)
*12*—*Nodosaria amphioxys* Reuss. Side view, ×44. (p. 103)
*13a–b*—*Pseudoglandulina scotti* Tappan, n. sp. *13a*, Side view; *b*, apertural view of holotype, ×55. (p. 105)
*14a–b*—*Pseudoglandulina* sp. *14a*, Side view; *b*, apertural view, ×55. (p. 105)
*15a–b*—*Pseudoglandulina* cf. *mutabilis* (Reuss), *15a*, Side view; *b*, apertural view, ×55. (p. 105)
*16a–b*—*Saracenaria bononiensis* (Berthelin). *16a*, Side view; *b*, face view, showing median rib, ×55. (p. 105)
*17a–b*—*Saracenaria cushmani* Tappan, n. sp. *17a*, Side view; *b*, face view of holotype, ×55. (p. 106)
*18a–c*—*Lingulina furcillata* Berthelin. *18a*, Side view; *b*, edge view; *c*, apertural view, ×55. (p. 106)
*19*—*Lingulina lamellata* Tappan, n. sp. Side view of holotype, ×55. (p. 106)
*20a–b*—*Lingulina nodosaria* Reuss. *20a*, Side view; *b*, apertural view, ×55. (p. 107)
*21a–b*—*Lingulina nodosaria* Reuss var. *semiornata* Reuss. *21a*, Side view; *b*, apertural view, ×55. (p. 107)
*22a–b*—*Lingulina serrata* Tappan, n. sp. *22a*, Side view; *b*, apertural view of holotype, ×55. (p. 107)
*23a–24*—*Vaginulina complanata* (Reuss). *23a*, Side view; *b*, edge view, ×44. *24*, Side view of smaller specimen showing basal spine, ×55. (p. 107)
*25*—*Vaginulina complanata* (Reuss) var. *perstriata* Tappan, n. var. Side view of holotype, ×44. (p. 108)
*26a–b*—*Vaginulina debilis* (Berthelin). *26a*, Side view; *b*, apertural view, ×44. (p. 108)




Tappan, Cretaceous Foraminifera




Tappan, Cretaceous Foraminifera

chambers, as the chambers increase more gradually in height. This species is distinguished by its small size. It is fairly common throughout the Grayson formation.

Genus NEOBULIMINA Cushman and Wickenden, 1928

NEOBULIMINA MINIMA Tappan, n. sp.

Plate 19, figures 5a–6

Test minute, early stage triserial, later stage biserial, final pair of chambers forming approximately one-third of the test, slightly twisted, nearly circular in cross-section; chambers inflated, slightly elongate, wall calcareous, surface smooth, aperture broad, loop-shaped at the base of the last-formed chamber. Length of holotype, 0.26 mm; breadth, 0.10 mm; width, 0.08 mm; length of paratype, 0.21 mm; breadth, 0.09 mm.

*Type.*—Holotype (Cushman coll. no. 25100) from middle of zone 1, paratype (Cushman coll. no. 25101) from top of zone 1, Grayson Bluff.

*Remarks.*—This species is somewhat similar to *N. canadensis* Cushman and Wickenden (1928, p. 53), in size and general outline. *M. minima* n. sp. has a more pointed base and more regularly enlarging chambers, less depressed sutures (so that it has an almost circular cross-section) and a more slender form throughout. This species occurs abundantly throughout the Grayson formation, but may be overlooked because of its tiny size.

Subfamily VIRGULININAE

Genus VIRGULINA d'Orbigny, 1826

VIRGULINA MINUTA Cushman

Plate 19, figures 7a–b

*Virgulina minuta* CUSHMAN, *1936*, Cushman Lab. Foram. Research, Contr., Spec. Publ. 6, p. 47, pl. 7, figs. 3a–c; *1937*, Ibid., Spec. Publ. 9, p. 4, pl. 1, figs. 6–7.

The following description is from Cushman (1936 c):

Test small, slender, gradually tapering from the rounded base, in the adult with the sides nearly parallel, somewhat lobatulate, later portion somewhat compressed, about three times as long as broad, periphery broadly rounded; chambers numerous, distinct, depressed, strongly oblique to the periphery; wall smooth, finely perforate; aperture narrow, elongate, at the inner margin (of the last-formed chamber). Length, 0.25 mm; breadth, 0.08 mm; thickness, 0.06 mm.

---

EXPLANATION OF PLATE 17

FIGS. *1a–c—Vaginulina geisendörferi* Franke. *1a*, Side view; *b*, dorsal view; *c*, face view showing wide apertural face, ×55. (p. 109)

*2–4—Vaginulina kochii* Roemer. *2*, Side view of adult form, ×44. *3*, Side view of microspheric specimen of the type called *V. arguta* by European authors, ×44. *4*, Side view of young megalospheric form, ×55. (p. 109)

*5—Vaginulina kochii* Roemer var. *striolata* Reuss. Side view, ×44. (p. 110)

*6a–b—Vaginulina linearis* (Reuss). *6a*, Side view; *b*, cross-section to show acute dorsal margin, ×55. (p. 110)

*7a–8—Vaginulina recta* Reuss. *7a*, Side view; *b*, edge view, ×55. *8*, small specimen showing plastogamy, ×77. (p. 110)

*9–10—Marginulina tenuissima* Reuss. *9*, Adult specimen, ×44. *10*, Young specimen, ×55. (p. 101)

*11a–12b—Vaginulina tripleura* (Reuss). *11a*, Side view; *b*, apertural view. *12a*, Side view; *b*, face view, ×55. (p. 111)

*13a–14—Frondicularia* sp. *13a*, Side view; *b*, edge view of young specimen. *14*, Fragment of adult specimen, ×55. (p. 111)

*15a–b—Lagena apiculata* (Reuss). *15a*, Side view; *b*, apertural view, ×55. (p. 111)

*16a–b—Lagena hispida* Reuss var. *16a*, Side view; *b*, apertural view, ×55. (p. 112)

*17—Lagena leptata* Tappan, n. sp. Side view of holotype, ×55. (p. 112)

*18a–b—Lagena striatifera* Tappan, n. sp. *18a*, Side view; *b*, apertural view of holotype, ×55. (p. 112)

*19a–b—Lagena sulcata* (Walker and Jacob). *19a*, Side view; *b*, apertural view, ×55. (p. 112)

*20a–21c—Paleopolymorphina ozawai* Tappan, n. sp. *20a*, *b*, Two views of holotype, *21a*, *b*, side view of a paratype; *c*, edge view, ×55. (p. 113)

*22a–23, 25—Pseudopolymorphina roanokensis* Tappan, n. sp. *22a*, *b*, Side views of holotype showing inflated base, ×55. *23*, Large paratype showing well developed uniserial portion, ×55. *25*, Small specimen, × 55. (p. 113)

*24a–b—Globulina lacrima* Reuss var. *subspherica* (Berthelin). *24a*, *b*, Side views of fistulose specimen, ×55. (p. 113)

*Type.*—Topotype (Cushman coll. no. 25102) from middle of zone 1, Grayson Bluff. This is the type locality of this species, and one at which it is quite abundant.

### Genus BOLIVINA d'Orbigny, 1839
### BOLIVINA cf. TEXTILARIOIDES Reuss
### Plate 18, figures 8a–c

*Bolivina textilarioides* REUSS, *1863*, Akad. Wiss. Wien., Sitz., vol. 46, pt. 1, p. 81, pl. 10, figs. 1a–b.

*Bolivina textilarioides* CUSHMAN, *1937*, Cushman Lab. Foram. Research, Contr., Spec. Publ. 9, pp. 37–38, pl. 5, fig. 18.

The following description is from Cushman (1937 c):

Test elongate, tapering gradually, with the greatest width near the apertural end, slightly compressed, periphery rounded; chambers numerous, distinct, higher than broad, increasing rather regularly in size as added, and of uniform shape; sutures distinctly convex downward toward the initial end, slightly depressed; wall smooth; aperture narrow elongate, in the median line, reaching well into the terminal face from its inner margin.

*Type.*—Hypotype (Cushman coll. no. 25103) from base of zone 1, Grayson Bluff.

*Remarks.*—According to Cushman,

This is one of the earliest species of the genus known, and it should be noted that in many of its characters it resembles *Virgulina*, particularly in the rounded periphery, the sutures curved toward the initial end, and the characters of the aperture. The species, however, seems to be biserial throughout.

This species is rather rare in the Grayson formation and seems to show more twisting than does the specimen figured by Reuss.

### Genus BIFARINA Parker and Jones, 1872
### BIFARINA TENUILISSA Tappan, n. sp.
### Plate 18, figure 9

Test tiny, early portion biserial, later irregular and then uniserial; chambers inflated, globular; sutures distinct, depressed; wall calcareous, surface smooth; aperture terminal. Length of holotype, 0.52 mm; breadth, 0.07 mm;

*Type.*—Holotype (Cushman coll. no. 25104) from middle of zone 1, Grayson Bluff.

*Remarks.*—*B. tenuilissa* is similar in chamber development to *B. fimbriata* Millett, both having a short biserial stage and elongate uniserial portion. It differs in the smooth and simple chambers which lack ornamentation of any type. The chambers are globular, the sutures depressed and the aperture simple, while in *B. fimbriata* the chambers have a peripheral fimbriate ridge and are depressed between the ridges, while the aperture has a phialine lip. *B. tenuilissa* n. sp. is distinguished by its slender form, elongate uniserial portion and tiny biserial portion. Some specimens are apparently slightly arcuate. The species occurs rather sparingly in the Grayson.

### Subfamily UVIGERININAE
### Genus DENTALINOPSIS Reuss, 1860
### DENTALINOPSIS EXCAVATA (Reuss)
### Plate 18, figures 10a–b

*Rhabdogonium excavatum* REUSS, *1862*, Akad. Wiss. Wien., Sitz., vol. 46, p. 91, pl. 12, figs. 8a–c.

*Rhabdogonium excavatum* BERTHELIN, *1880*, Soc. Géol. France, Mém., ser. 3, vol. 1, mem. 5, p. 47.

? *Rhabdogonium minutum* BURROWS, SHERBORN and BAILEY, *1890*, Roy. Micr. Soc., Jour., p. 559, pl. 10, fig. 8.

*Rhabdogonium excavatum* CHAPMAN, *1894*, Roy. Micr. Soc., Jour., p. 160, pl. 4, figs. 9a–b.

*Rhabdogonium excavatum* EGGER, *1899*, Bayer Akad. Wiss. München, Abh., Cl. 2, vol. 21, p. 92, pl. 17, figs. 23–24.

*Rhabdogonium excavatum* FRANKE, *1925*, Griefswald, Univ. Geol.-Paleont. Inst., Abh., vol. 6, p. 53, pl. 4, fig. 20.

*Clavulina* sp. MARGARET CARPENTER, *1925*, Texas Univ. Bull. 2544, pl. 16, fig. 4.

*Rhabdogonium excavatum* FRANKE, *1928*, Preuss. geol. Landesanstalt, Abh., n. ser., vol. 111, pt. 3, p. 73, pl. 6, figs. 22a–b.

*Dentilinopsis excavata* PLUMMER, *1931*, Texas Univ. Bull. 3101, p. 187, pl. 11, figs. 11–12.

The following description is from Plummer (1931 b):

Test elongate, tricarinate, straight to slightly arcuate; chambers uniserial from a globular proloculum, short, triangular in cross-section with concave lateral faces, curved downward, lobate along lateral edges with an occasional posterior projection in the form of a blunt spine; sutures excavated; aperture a terminal round opening. Average length, 0.45 mm; breadth, 0.18 mm.

*Type.*—Hypotype (Cushman coll. no. 25105) from base of zone 1, Grayson Bluff.

*Remarks.*—According to Plummer,

Most tests of this species in the Texas strata are straight but some unusually well developed and unusually long tests show a slight curvature. The degree of lateral excavation and the degree of

angularity of the lateral angles vary amongst specimens from the same sample.

Length of hypotype, 0.69 mm; width across one face, 0.19 mm. This species is common in the Grayson and Del Rio and ranges throughout the Washita group.

### DENTALINOPSIS MÄRTENSI (Reuss)
Plate 18, figures 11a–c

*Rhabdogonium märtensi* REUSS, *1863*, Akad. Wiss. Wien., Sitz., vol. 46, p. 56, pl. 5, fig. 4.
*Rhabdogonium maertensi* CHAPMAN, *1894*, Roy. Micr. Soc., Jour., p. 160, pl. 4, figs. 10a–b.

Test generally short, quadrate, uniserial throughout; chambers extending farthest down on each of the four corners, increasing in height as added, but expanding only slightly; sutures distinct, depressed, highly arched in the middle of each side of the test; wall calcareous, smooth; aperture terminal, rounded. Length of hypotype, 0.46 mm; breadth of side, 0.14 mm; width through center, from centers of opposite faces, 0.13 mm.

*Type.*—Hypotype (Cushman coll. no. 25106) from base of zone 1, Grayson Bluff.

*Remarks.*—This species occurs sparingly throughout the Washita group. It is distinguished from *D. excavata* (Reuss) in its four-sided character and smaller size. It rarely has as many chambers as *D. excavata*.

### DENTALINOPSIS SUBQUADRATA
Tappan, n. sp.
Plate 18, figures 12a–c

Test broad, uniserial, irregularly lineate, faintly quadrate in outline, last chamber rounded; chambers inflated, increasing gradually in width; sutures faint, slightly depressed; wall calcareous, smooth; aperture rounded, terminal. Length of holotype, 0.59 mm; greatest diameter of final chamber, 0.30 mm.

*Type.*—Holotype (Cushman coll. no. 25107) from lower part of zone 1, Grayson Bluff.

*Remarks.*—This species differs from *D. märtensi* (Reuss), the only other quadrate species in the Grayson, in its larger size, broader test and more rounded angles. It expands gradually while *D. märtensi* is of equal width throughout its length. It occurs sparingly throughout the Grayson.

### DENTALINOPSIS TRICARINATUM (Reuss) VAR. ACUTANGULUM Reuss
Plate 18, figures 13a–c

*Rhabdogonium tricarinatum* REUSS var. *acutangulum* REUSS, *1863*, Akad. Wiss. Wien., Sitz., vol. 46, p. 55, pl. 4, figs. 14a–b.
*Rhabdogonium tricarinatum* var. *acutangulum* CHAPMAN, *1894*, Roy. Micr. Soc., Jour., pp. 159–160, pl. 4, figs. 8a–b.

Test medium in size, triangular in section, faces concave; chambers increasing rapidly in early stage; sutures distinct, slightly thickened, arched in a broad and regular curve; wall calcareous, surface smooth, a carinate keel at the angles of the test; aperture terminal, rounded. Length of hypotype 0.57 mm; width of side, 0.37 mm.

*Type.*—Hypotype (Cushman coll. no. 25108) from top of zone 1, Grayson Bluff.

*Remarks.*—This species differs from *D. excavata* (Reuss) in the more flaring character of the test, the concave faces and the more highly and more evenly arched sutures. *D. excavata* is approximately the same width throughout its length, or slightly flaring. *D. tricarinatum* var. *acutangulum* occurs sparingly throughout the Washita group.

## Family ROTALIIDAE
## Subfamily SPIRILLININAE
## Genus SPIRILLINA Ehrenberg, 1843
### SPIRILLINA MINIMA Schacko
Plate 19, figure 8

*Spirillina minima* SCHACKO, *1892*, Foram. u. Ostra. a. d. Kreide von Moltzow, p. 159, pl. I, fig. 4.
*Spirillina minima* FRANKE, *1928*, Preuss. geol. Landesanstalt, Abh., n. ser., vol. 111, p. 16, pl. 1, fig. 16.

Test minute, free, planispiral, proloculum comparatively large, rounded, second chamber long, undivided, tubular, closely coiled; wall calcareous, finely perforate, aperture formed by the open end of the tube. Maximum diameter of hypotype, 0.19 mm.

*Type.*—Hypotype (Cushman coll. no. 25109) from base of zone 1, Grayson Bluff.

*Remarks.*—This form is distinguished by its small size and comparatively large proloculum. It is more abundant in the lower third of the Grayson but ranges throughout. It was originally described from Germany.

Subfamily DISCORBINAE
Genus VALVULINERIA Cushman, 1926
VALVULINERIA ASTERIGERINOIDES
Plummer
Plate 19, figures 9a–c

*Anomalina* sp. MARGARET CARPENTER, *1925*, Texas Univ. Bull. 2544, pl. 17, figs. 9–10.
*Valvulineria asterigerinoides* PLUMMER, *1931*, Texas Univ. Bull. 3101, p. 190, pl. 14, fig. 6.

The following description is from Plummer (1931 b):

Test small, round to somewhat elliptical in outline, slightly lobate; periphery broadly rounded; dorsal face somewhat depressed; ventral face gently convex with a broadly excavated umbilicus that is surrounded by a star-shaped pattern formed by the overlap of successive umbilical flaps; chambers seven to eight in mature convolution, last two or three slightly turgid; sutures almost radiate on both sides, slightly depressed between last few chambers; aperture near umbilical area under a broad conspicuous flap that marks the posterior side of each chamber. Longest diameter of holotype, 0.34 mm; shortest diameter, 0.26 mm; thickness through last chamber, 0.15 mm.

Maximum diameter of hypotype, 0.28 mm; minimum diameter, 0.21 mm; thickness through center, 0.08 mm.

*Type.*—Hypotype (Cushman coll. no. 25110) from middle of zone 1, Grayson Bluff.

*Remarks.*—According to Plummer,

The most striking characteristic of this . . . species is the ventral stellar pattern formed by the overlapping successive broad umbilical flaps. The general structure of the trochoid coil is typical of the genus *Valvulineria* with the early convolutions depressed beneath the level of the last convolution on the dorsal side and with its almost radiate sutures.

The species is common throughout the Grayson formation.

Genus GYROIDINA d'Orbigny, 1826
GYROIDINA LOETTERLEI Tappan, n. sp.
Plate 19, figures 10a–c

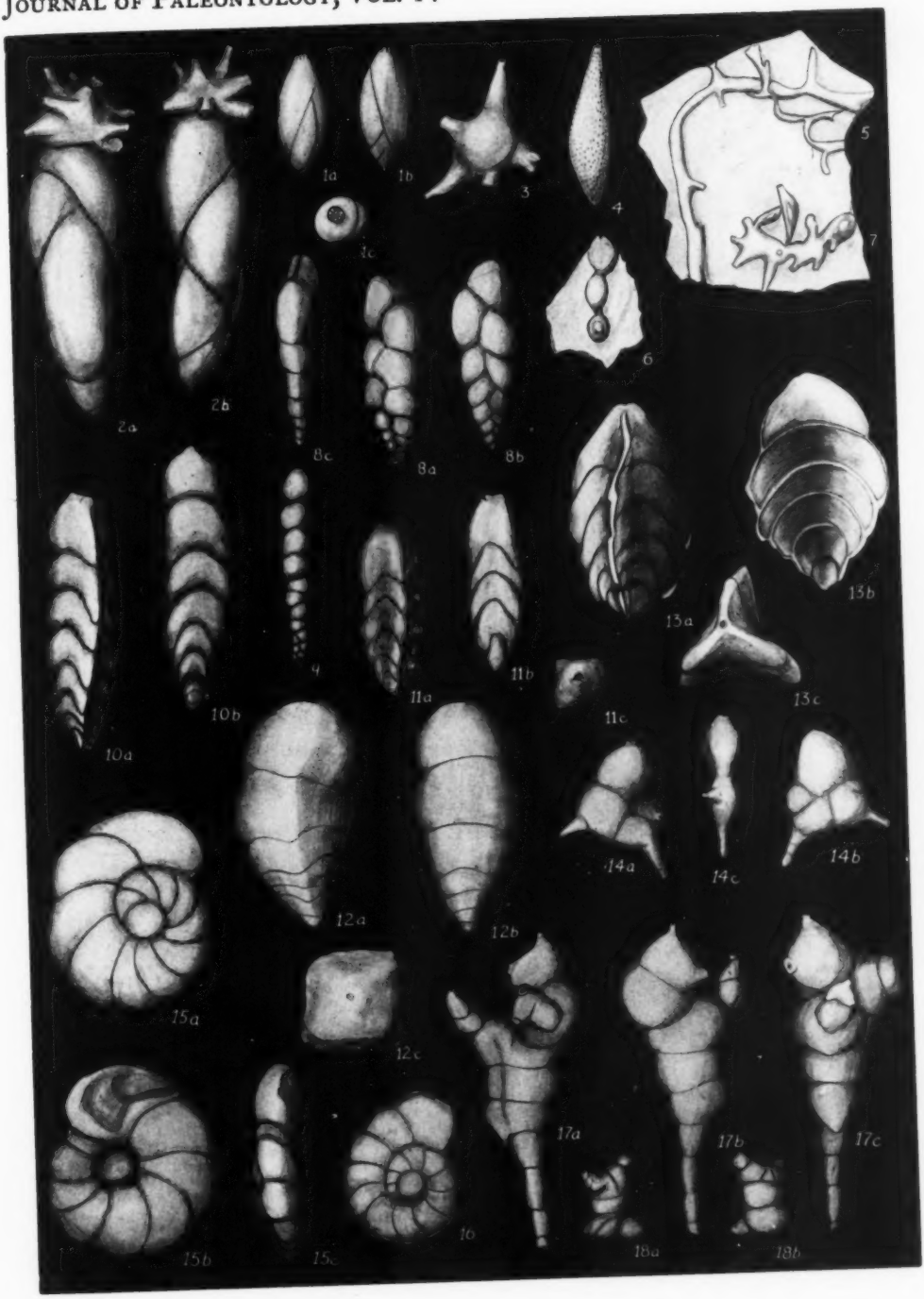
*Pulvinulina* sp. MARGARET CARPENTER, *1925*, Texas Univ. Bull. 2544, pl. 17, figs. 11, 12.
*Gyroidina nitida* PLUMMER, *1931* (not *Rotalina nitida* REUSS, 1844), Texas Univ. Bull. 3101, p. 191, pl. 14, fig. 5.

Test small, nearly circular in outline, generally with two to two and one-half convolutions, periphery broadly rounded, dorsal side gently convex, ventral side slightly depressed around the broad umbilical flap, which is a posterior extension of the last chamber; six to seven chambers in last whorl, chambers thick and rounded; sutures faintly depressed in the early chambers, and distinctly depressed in the later chambers of large specimens, giving a faintly lobulate appearance, sutures slightly convex toward the last chamber; wall calcareous, smooth; aperture a narrow slit at the base of the septal face, extending toward the umbilicus.

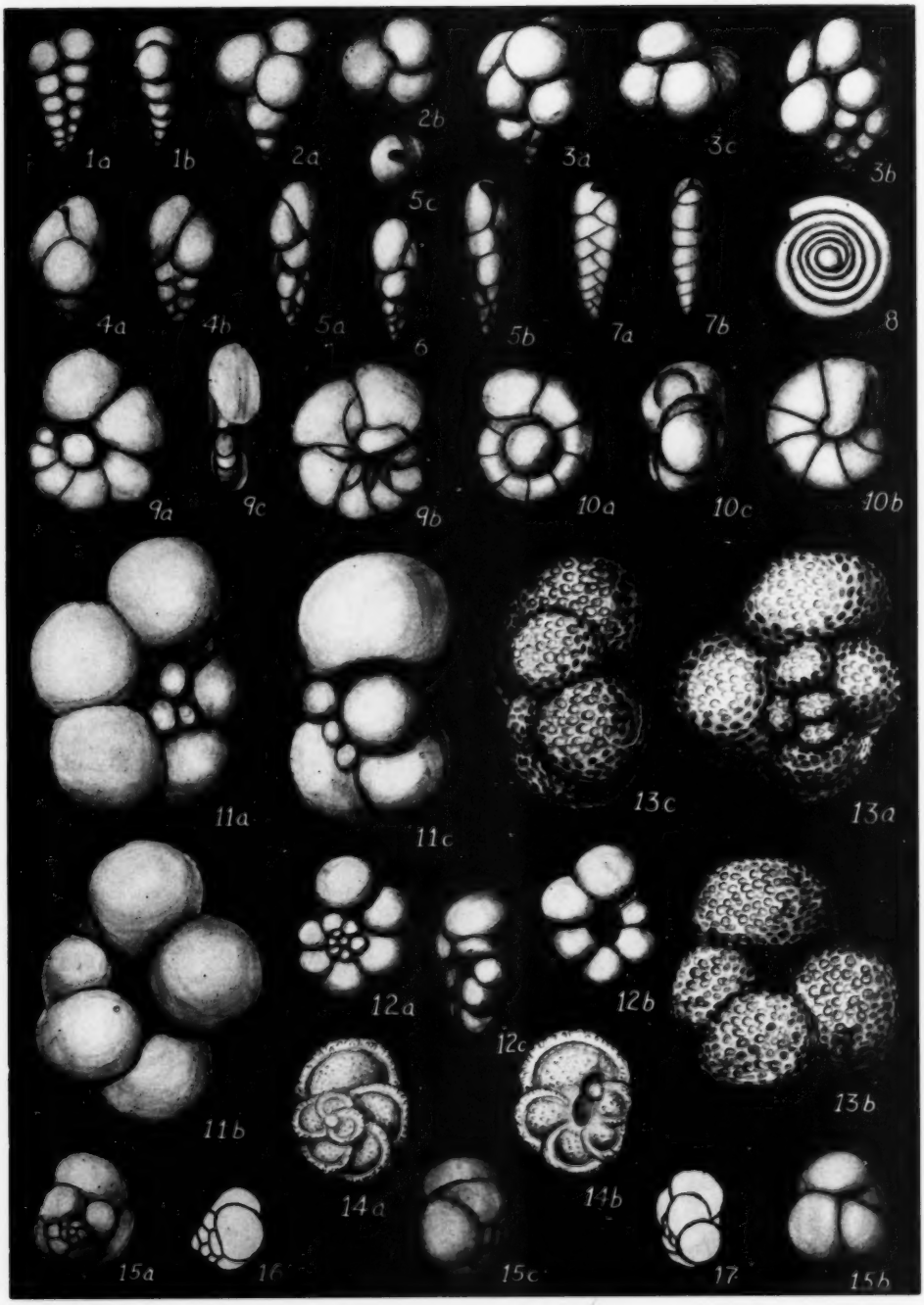
---

EXPLANATION OF PLATE 18

FIGS. *1a–c—Pyrulina cylindroides* (Roemer). *1a, b*, Side views; *c*, apertural view, ×55. (p. 114)
*2a–b—Pyrulina longa* Tappan, n. sp. *2a, b*, Side views, ×55. (p. 114)
*3—Ramulina* cf. *globulifera* Brady, ×44. (p. 114)
*4—Ramulina* sp., ×26. (p. 114)
*5—Bullopora cervicornis* (Chapman). Long branching specimen at upper left on shell fragment, ×10. (p. 114)
*6—Bullopora laevis* (Sollas), ×10. (p. 115)
*7—Bullopora* sp. Small specimen on lower right of same shell fragment as in fig. 5, ×10. (p. 115)
*8a–c—Bolivina* cf. *textilarioides* Reuss. *8a, b*, Side views; *c*, edge view, ×55. (p. 118)
*9—Bifarina tenuilissa* Tappan, n. sp. Side view of holotype, ×55. (p. 118)
*10a–b—Dentalinopsis excavata* (Reuss). *10a*, Side view; *b*, face view, ×55. (p. 118)
*11a–c—Dentalinopsis märtensi* (Reuss). *11a*, Side view; *b*, face view; *c*, apertural view, ×55. (p. 119)
*12a–c—Dentalinopsis subquadrata* Tappan, n. sp. *12a*, Side view; *b*, face view; *c*, apertural view, ×55. (p. 119)
*13a–c—Dentalinopsis tricarinatum* (Reuss) var. *acutangulum* Reuss. *13a*, Side view; *b*, face view; *c*, apertural view, ×55. (p. 119)
*14a–c—Schackoina primitiva* Tappan, n. sp. *14a*, Dorsal view; *b*, ventral view; *c*, edge view, ×55. (p. 123)
*15a–16—Anomalina plummerae* Tappan, n. sp. *15a*, Dorsal view; *b*, ventral view; *c*, edge view of holotype, ×44. *16*, Dorsal view of paratype, ×55. (p. 124)
*17a–18b—Genus* (?) *species* (?). *17a, b, c*, Three different views of a large specimen. *18a, b*, Two views of a small specimen, ×55. (p. 124)




Tappan, Cretaceous Foraminifera




Tappan, Cretaceous Foraminifera

Greatest diameter of holotype 0.23 mm; least diameter 0.18 mm; thickness 0.14 mm. According to Plummer the average diameter is 0.28 mm; and the average thickness 0.14 mm.

*Type.*—Holotype (Cushman coll. no. 25111) from middle of zone 1, Grayson Bluff.

*Remarks.*—According to Plummer,

> This small and subglobular test is especially distinctive for its umbilical flap which is the strongly exaggerated development of a small posterior point of the final chamber of many of its cogenors in other Texas strata. Because it fits very closely the body of the coil, it is well preserved on most tests.

This species ranges throughout the Washita and is abundant in the Del Rio and Grayson. The Grayson specimens generally show a somewhat plug-like appearance at the umbilicus on the dorsal side, and the sutures are generally very slightly depressed, while the Del Rio forms show the earlier whorls more distinctly and the sutures are more depressed, so that the chambers are almost lobulate.

*G. loetterlei*, n. sp. differs from *Valvulineria plummerae* Loetterle in the slightly smaller size, greater thickness and fewer chambers, which are six to seven in the last whorl, as compared to eight or nine in *V. plummerae*. *G. loetterlei* differs from *G. nitida* (Reuss) in the more numerous chambers, which are four to six in the last whorl of *G. nitida*, in the lower ventral face and in the presence of the much larger ventral umbilical flap.

This species is named for Dr. G. J. Loetterle, who first called to the writer's attention the distinctness of this species from *G. nitida* (Reuss). In 1937 the Washita species was included in the synonymy of the new species *Valvulineria plummerae* Loetterle, from the Niobrara. In a personal communication, Dr. Loetterle said that the Washita species, which is here named *G. loetterlei*, is distinct from the Niobrara form.

Family GLOBIGERINIDAE
Subfamily GLOBIGERININAE
Genus GLOBIGERINA d'Orbigny, 1826
GLOBIGERINA CRETACEA d'Orbigny
Plate 19, figures 11a–c

*Globigerina cretacea* d'ORBIGNY, *1840*, Soc. géol. France Mém., ser. 1, vol. 4, p. 34, pl. 3, figs. 12–14.

*Globigerina cretacea* REUSS, *1845*, Verstein. Böhm. Kreidef., Stuttgart, vol. 6, p. 36, pl. 8, figs. 55a–b.

*Globigerina cretacea* BURROWS, SHERBORN and BAILEY, *1890*, Roy. Micr. Soc., Jour., pt. 5, p. 561, pl. 11, figs. 18a–c.

*Globigerina cretacea* CHAPMAN, *1892*, vol. 48, pl. 15, figs. 13a–c; Quart. Jour. Geol. Soc. London; *1896*, Jour. Roy. Micro. Soc., pp. 588–589, pl. 13, figs. 5a–c, 6.

---

EXPLANATION OF PLATE 19

FIGS. *1a–b—Gümbelina washitensis* Tappan, n. sp., *1a*, Side view; *b*, edge view of holotype, ×82. (p. 115)

*2a–b—Gümbelitria harrisi* Tappan, n. sp. *2a*, Side view; *b*, apertural view of holotype, ×82. (p. 115)

*3a–c—Gümbelitriella graysonensis* Tappan, n. gen., n. sp. *3a*, *b*, Side views of holotype; *c*, apertural view, ×82. (p. 116)

*4a–b—Bulimina nannina* Tappan, n. sp. *4a*, *b*, Side views of holotype, ×82. (p. 116)

*5a–6—Neobulimina minima* Tappan, n. sp. *5a*, *b*, Side views of holotype; *c*, apertural view; *6*, Side view of paratype, ×82. (p. 117)

*7a–b—Virgulina minuta* Cushman. *7a*, Side view; *b*, edge view, ×82. (p. 117)

*8—Spirillina minima* Schacko. Side view, ×82. (p. 119)

*9a–c—Valvulineria asterigerinoides* Plummer. *9a*, Dorsal view; *b*, ventral view; *c*, edge view, ×82. (p. 120)

*10a–c—Gyroidina loetterlei* Tappan, n. sp. *10a*, Dorsal view; *b*, ventral view; *c*, edge of holotype, ×82. (p. 120)

*11a–c—Globigerina cretacea* d'Orbigny. *11a*, Dorsal view; *b*, ventral view; *c*, edge view, ×66. (p. 121)

*12a–c—Globigerina planispira* Tappan, n. sp. *12a*, Dorsal view; *b*, ventral view; *c*, edge view of holotype, ×82. (p. 122)

*13a–c—Globigerina washitensis* Carsey. *13a*, Dorsal view; *b*, ventral view; *c*, edge view, ×66. (p. 122)

*14a–b—Globorotalia delrioensis* Plummer. *14a*, Dorsal view; *b*, ventral view, ×82. (p. 123)

*15a–17—Globigerina graysonensis* Tappan, n. sp. *15a*, Dorsal view; *b*, ventral view; *c*, edge view of holotype. *16*, *17*, Edge views of paratypes to show variation in elevation of spire, ×82. (p. 122)

*Globigerina cretacea* EGGER, *1907*, Nat. Ver. Nassau, Ber., 20, p. 49, pl. 6, fig. 23; *1910*, Nat. Ver. Regensburg, Bericht, p. 121, pl. 4, fig. 21.

Test large, very thick, in a trochoid spire of about two volutions, four to five chambers in a whorl, chambers much inflated, globular; sutures distinct, constricted; wall calcareous, surface smooth; aperture opening into the umbilicus. Greatest diameter of hypotype, 0.61 mm; shortest diameter, 0.40 mm; width, 0.27 mm.

*Type.*—Hypotype (Cushman coll. no. 25112) from top of zone 1, Grayson Bluff.

*Remarks.*—This species is characterized by its bulbous appearance and great width, the chambers having their greatest dimension in thickness. The species is abundant throughout the Washita, comprising a large percentage of the microfauna in some samples. It has been recorded from Cretaceous to Recent.

GLOBIGERINA GRAYSONENSIS
Tappan, n. sp.
Plate 19, figures 15a–17

Test tiny, trochoid, dorsal side varying from flattened to a rather high spire; chambers numerous, inflated, globular, from three to five in a whorl; sutures distinct, depressed; wall calcareous, smooth, aperture slit-like, at the lower margin of the last chamber, extending from a point near the center of the ventral side outward to a point approximately one-half the distance to the periphery, partially covered by a lip. Greatest diameter of holotype, 0.21 mm; least diameter, 0.17 mm; width through center, 0.16 mm; average diameter, 0.135 to 0.17 mm.

*Type.*—Holotype (Cushman coll. no. 25117) from middle of zone 1, paratype of figure 16 (Cushman coll. no. 25118) from middle of zone 1, and paratype of figure 17 (Cushman coll. no. 25119) from base of zone 1, Grayson Bluff.

*Remarks.*—This species is fairly common throughout the Grayson formation. *G. graysonensis* is similar in general appearance and chamber arrangement to *Candeina nitida* d'Orbigny, having approximately the same number of chambers. low spire and smooth wall. It differs in lacking the multiple aperture of the adult *Candeina*, is approximately one-fifth as large, and has smooth chambers throughout. The generic identification of this species is somewhat in doubt. It resembles *Globigerina* in being trochoid and in having nearly globular chambers, but differs somewhat in the character of the aperture, as this species has an aperture which extends toward the periphery. It resembles *Rotaliatina* in being fairly high-spired, having only a few chambers in a whorl, but differs in that the aperture extends to the center of the ventral side, the chambers are globular and the spire is lower. It resembles *Eponides* in the trochoid character and aperture but is not as biconvex and has more globular chambers than the typical *Eponides*.

GLOBIGERINA PLANISPIRA
Tappan, n. sp.
Plate 19, figures 12a–c

Test tiny, in a low trochoid spire of two volutions; chambers six to seven in a whorl, increasing rapidly in size, bulbous; sutures distinct and constricted; wall calcareous, surface smooth; aperture opening into a deep umbilical excavation. Longest diameter of holotype, 0.24 mm; shortest diameter, 0.18 mm; width through center 0.11 mm.

*Type.*—Holotype (Cushman coll. no. 25113) from upper part of zone 1, Grayson Bluff.

*Remarks.*—*G. planispira* differs from *G. cretacea* d'Orbigny in its much smaller size, more numerous chambers in each whorl and comparatively smaller width. More whorls are visible than in *G. cretacea*. It is present throughout the Washita group, although it is less abundant than *G. cretacea*.

GLOBIGERINA WASHITENSIS
Carsey
Plate 19, figures 13a–c

*Globigerina* sp. MARGARET CARPENTER, *1925*, Texas Univ. Bull. 2544, pl. 17, fig. 5.
*Globigerina washitensis* CARSEY, *1926*, Texas Univ. Bull. 2612, p. 44, pl. 7, fig. 10, pl. 8, fig. 2.
*Globigerina washitensis* PLUMMER, *1931*, Texas Univ. Bull. 3101, p. 193, pl. 13, fig. 12.

The following description is from Plummer (1931 b):

Test compact, with moderately appressed globular chambers in a low trochoid spire of two

or two and one-half convolutions; chambers from three and one-half to as many as six in a whorl; surface coarsely and conspicuously marked into rather polygonal areas by exogenous ridges that form a honeycomb pattern over the whole test; aperture at base of final chamber opening into a deep umbilical excavation. Longest diameter of neoholotype, 0.42 mm; shortest diameter, 0.32 mm; thickness through spire, 0.22 mm.

Longest diameter of hypotype, 0.53 mm; shortest diameter, 0.38 mm; thickness through spire, 0.30 mm.

*Type.*—Hypotype (Cushman coll. no. 25114) from base of zone 1, Grayson Bluff. The species ranges throughout the Washita group and is fairly common in the Grayson formation.

Family HANTKENINIDAE
Genus SCHACKOINA Thalmann, 1932
SCHACKOINA PRIMITIVA
Tappan, n. sp.
Plate 18, figures 14a–c

Test tiny, biumbilicate, slightly trochoid; chambers inflated at their center, about three chambers to a whorl, increasing rapidly in size, each with a fairly thick hollow spine, arising from the center of the chamber on the periphery, about equal in length to one-half the diameter of the test; sutures distinct, slightly depressed, periphery slightly lobulate; wall calcareous, surface smooth; aperture a small arched slit at the base of the last chamber on the periphery. Greatest diameter of holotype, not including spines, 0.265 mm; least diameter, 0.17 mm; width through center, 0.06 mm; width of last chamber, 0.10 mm; length of spine, 0.10 mm.

*Type.*—Holotype (Cushman coll. no. 25115) from lower part of zone 1, Grayson Bluff.

*Remarks.*—This is one of the earliest species of *Schackoina* and is primitive in many of its characters. It is very tiny, the periphery is fairly even, without the characteristic lobulation of the genus, the chambers are few in number, the spines are short, and on the holotype the earliest spine is not directly on the periphery but slightly to one side, giving the trochoid appearance. Three of the spines were broken, only one being intact on the holotype. *S. primitiva* n. sp. is somewhat similar to *Hantkenina alabamensis* Cushman (1924, p. 3), in the rounded periphery, broken only by the spines. It differs in the fewer number of chambers, slightly trochoid character and the shorter, blunter and thicker peripheral spines, which originate from the central portions of the chambers and not at the sutures as in the case of *H. alabamensis*. This species is extremely rare, only two specimens having been seen by the writer.

Family GLOBOROTALIIDAE
Genus GLOBOROTALIA Cushman, 1927
GLOBOROTALIA DELRIOENSIS
Plummer
Plate 19, figures 14a–b

*Globigerina rosetta* CARSEY, *1926* (not *Globotruncana arca* CUSHMAN), Texas Univ. Bull. 2612, p. 44, pl. 5, figs. 3a–c.
*Globorotalia delrioensis* PLUMMER, *1931*, Texas Univ. Bull. 3101, p. 199, pl. 13, fig. 2.

The following description is from Plummer (1931 b):

Test broadly elliptical to round in peripheral outline, strongly lobate, singly carinate, about equally biconvex, periphery marked by short, conspicuous, spinose processes; chambers five or six in each convolution, roughened somewhat by small blunt beadlike elevations of shell matter especially toward the peripheral margin on each side; dorsal suture marked by beaded shell material, moderately curved; ventral sutures depressed and radiate; umbilicus distinct, small, shallow, closed; aperture a narrow slit on the inner edge of the base of the septal face under a narrow extended rim.

Average diameter, about 0.3 mm; greatest diameter of hypotype, 0.25 mm; least diameter, 0.20 mm.

*Type.*—Hypotype (Cushman coll. no. 25116) from top of zone 1, Grayson Bluff.

*Remarks.*—According to Plummer,

The shape of the chambers, the number per whorl, and the convexity of the dorsal face combine to make the Del Rio form almost identical with *G. crassata* (Cushman) as it occurs at the type locality in the Eocene of Mexico. The much lower convexity of the ventral face of this Lower Cretaceous form, however, serve to distinguish it.

This species was identified by Carsey as the same as *Globigerina rosetta* Carsey (=*Globotruncana arca* Cushman) of the Upper Cretaceous. The two are not identical. *G. delrioensis* Plummer occurs rarely in the Del Rio and is of varying abundance throughout the Grayson.

Family ANOMALINIDAE
Subfamily ANOMALININAE
Genus ANOMALINA d'Orbigny, 1826
ANOMALINA PLUMMERAE
Tappan, n. sp.
Plate 18, figures 15a–16

*Anomalina petita* CARSEY, *1926* (*nom. nud.*), Texas Univ. Bull. 2612, p. 48 (through error a cristellarian test represents this species on pl. 7, fig. 31.)

*Anomalina falcata* PLUMMER, *1931* (not *Truncatulina falcata* REUSS, 1869), Texas Univ. Bull. 3101, p. 202, pl. 14, figs. 7–8.

The following description is from Plummer (1931 b):

Test somewhat elongate, elliptical, much compressed, biconvex, periphery bluntly acute, central portion of dorsal face marked by a conspicuous boss that obscures the inner whorl; chambers nine to 10 in final whorl, last few slightly turgid; sutures thick but not elevated on dorsal side, slightly elevated on ventral side, distinctly curved across whorl; aperture a small arch over the periphery and extending down slightly on the ventral side. Average longest diameter, 0.45 mm; shortest diameter, 0.35 mm; thickness through central boss, 0.15 mm.

Greatest diameter of holotype, 0.66 mm; least diameter, 0.51 mm; greatest thickness, 0.22 mm.

*Type.*—Holotype (Cushman coll. no. 25120) and paratype (Cushman coll. no. 25121) from middle part of zone 1, Grayson Bluff.

*Remarks.*—This is not the same species as *A. falcata* (Reuss) as was stated by Plummer. The latter is an Oligocene form which has more numerous chambers in the last whorl, a less lobulate margin, a sharper periphery, and is less involute ventrally. In *A. plummerae* n. sp. the last few chambers enlarge rapidly while in *A. falcata* (Reuss) they enlarge very gradually. *A. plummerae* is somewhat similar to *A. complanata* Berthelin (Reuss?) but the latter is more involute and displays a less dorsal central coiling. This species occurs throughout the Grayson formation and the specimens average much larger than those of the lower Washita. It ranges throughout the Washita.

POSITION UNCERTAIN
GENUS (?) SPECIES (?)
Plate 18, figures 17a–18b

Test elongate, irregular, composed of numerous chambers arranged in a somewhat linear series at first, later branching irregularly; chambers inflated, varying in proportions from elongate to globular to flattened in the same specimen; wall calcareous, surface smooth; apertures simple, rounded, at the ends of slight necks on the last chambers of the linear series. Total length of specimen of figure 17, 0.83 mm; breadth of last chamber before branching, 0.25 mm; width of same chamber, 0.20 mm; height of chamber 0.14 mm; height of chamber of uniserial portion, 0.09 mm; breadth of early chamber, 0.05 mm.

*Type.*—Large figured specimen (Cushman coll. no. 25122) and small specimen (Cushman coll. no. 25123) from lower part of zone 1, Grayson Bluff.

*Remarks.*—This form apparently does not fit any of the genera thus far described and its position is extremely doubtful.Some specimens resemble the genus *Schackoina*, as do the later chambers of the specimen in figure 17. The recent forms *Calcituba polymorpha* Roboz and *Sporadogenerina flintii* Cushman have a somewhat similar irregular appearance and the Grayson form may later be found to belong to one of these genera. A further study of additional specimens will be necessary before a decision can be made as to its taxonomic position. It is found in varying abundance throughout the Grayson formation, but has not been seen elsewhere to the writer's knowledge.

REFERENCES

ADKINS, W. S., SELLARDS, E. H. and PLUMMER, F. B., *1932*, Geology of Texas, vol. 1, Stratigraphy, part 2, Mesozoic Systems in Texas, *Texas Univ. Bull.* 3232, pp. 259–517, figs. 13 to 26.

BERTHELIN, M., *1880*, Memoire sur les Foraminiferes fossiles de l'Etage Albien de Moncley (Doubs), *Soc. Géol. France Mem.*, Ser. 3, vol. 1, mem. 5, 84 pp., 4 pls.

BRADY, H. B., *1884*, Report of the Scientific Results of the Voyage of H. M. S. Challenger during the years 1873–1876, *Rept. Voy. Challenger, Zoology*, vol. 9.

BULLARD, FRED M., *1931*, Geology of Grayson County, Texas, *Texas Univ. Bull.* 3125, 72 pp. 4 figs., map.

BURROWS, H. W., SHERBORN, C. D. and BAILEY, GEORGE, *1890*, The Foraminifera of the Red Chalk of Yorkshire, Norfolk and Lincolnshire, *Roy. Micr. Soc., Jour.*, pt. 5, pp. 549–566, pls. 8–11.

CARPENTER, MARGARET, *1925*, Micrology of the Upper Washita, in WINTON, W. M., The Geology of Denton County, *Texas Univ. Bull.* 2544, pp. 71–74, pl. 16, 17 and 23, fig. 1.

CARSEY, DOROTHY OGDEN, *1926*, Foraminifera of the Cretaceous of Central Texas, *Texas. Univ. Bull.* 2612, 56 pp., 8 pls.

CHAPMAN, FREDERICK, *1892*, Microzoa from the Phosphatic Chalk of Taplow, *Geol. Soc. London Quart. Jour.*, vol. 48, pp. 514–518, 1 pl.

——, *1892–1898*, The Foraminifera of the Gault of Folkestone, 10 parts, *Roy. Micr. Soc., Jour.*, 18 pls.

——, *1917*, XI Monograph of the Foraminifera and Ostracoda of the Gingin Chalk, *Geol. Surv. West. Australia*, Bull. 72, 81 pp., 14 pls.

——, *1926*, Cretaceous and Tertiary Foraminifera of New Zealand with an appendix on the Ostracoda, *New Zealand Dept. Mines, Geol. Surv. Palaeont. Bull.* 11, 120 pp., 22 pls.

CUSHMAN, JOSEPH A., *1924*, A new genus of Eocene Foraminifera, *U. S. Nat. Mus. Proc.*, vol. 66, art. 30, pp. 1–4, pls. 1–2.

——, and WICKENDEN, R. T. D., *1928*, A new Foraminiferal genus from the Upper Cretaceous, *Cushman Lab. Foram. Res., Contr.*, vol. 4, pt. 1, pp. 12–14, pl. 1.

——, and ALEXANDER, C. I., *1930*, Some Vaginulinas and other Foraminifera from the Lower Cretaceous of Texas, *Cushman Lab. Foram. Res., Contr.*, vol. 6, pt. 1, pp. 1–10, pl. 3.

——, and WICKENDEN, R. T. D., *1930*, The development of *Hantkenina* in the Cretaceous with a description of a new species, *Cushman Lab. Foram. Res., Contr.*, vol. 6, pt. 2, pp. 39–43, pl. 6.

——, and OZAWA, YOSHIAKI, *1930*, A monograph of the Foraminiferal family Polymorphinidae, recent and fossil, *U. S. Nat. Mus. Proc.*, vol. 77, art. 6, 185 pp., 40 pls.

——, *1932*, *Textularia* and related forms from the Cretaceous, *Cushman Lab. Foram. Res., Contr.*, vol. 8, pt. 4, pp. 86–97, pl. 11.

——, *1933*, Relationships and geologic distribution of the genera of the Valvulinidae, *Cushman Lab. Foram. Res., Contr.*, vol. 9, pt. 2, pp. 38–44, pl. 4.

——, *1933*, Foraminifera, their classification and economic use, 2nd edition, *Cushman Lab. Foram. Res., Contr., Spec. Publ.* 4, 349 pp., 31 pls.

——, *1933*, An illustrated key to the genera of the Foraminifera, *Cushman Lab. Foram. Res., Contr., Spec. Publ.* 5, 26 pp., 40 pls.

——, and PARKER, FRANCES L., *1935*, Some American Cretaceous Buliminas, *Cushman Lab. Foram. Res., Contr.*, vol. 11, pt. 4, pp. 96–101, pl. 15.

——, and PARKER, FRANCES L., *1936*, Notes on some Cretaceous species of *Buliminella* and *Neobulimina*, *Cushman Lab. Foram. Res., Contr.*, vol. 12, pt. 1, pp. 5–10, pl. 2.

——, *1936*, Notes on some American Cretaceous Frondicularias, *Cushman Lab. Foram. Res., Contr.*, vol. 12, pt. 1, pp. 11–22, pl. 4.

——, *1936*, New genera and species of the families Verneuilinidae and Valvulinidae and of the subfamily Virgulininae, *Cushman Lab. Foram. Res., Contr., Spec. Publ.* 6, 71 pp., 8 pls.

——, *1937*, A monograph of the foraminiferal family Verneuilinidae, *Cushman Lab. Foram. Res., Contr., Spec. Publ.* 7, 170 pp., 20 pls.

——, *1937*, A monograph of the foraminiferal family Valvulinidae, *Cushman Lab. Foram. Res., Contr., Spec. Publ.* 8, 210 pp., 24 pls.

——, *1937*, A monograph of the subfamily Virgulininae of the foraminiferal family Buliminidae, *Cushman Lab. Foram. Res., Contr., Spec. Publ.* 9, 240 pp., 24 pls.

——, *1937*, Some notes on Cretaceous species of *Marginulina*, *Cushman Lab. Foram. Res., Contr.*, vol. 13, pt. 4, pp. 91–99, pls. 13–14.

——, *1937*, A few new species of American Cretaceous foraminifera, *Cushman Lab. Foram. Res., Contr.*, vol. 13, pt. 4, pp. 100–105, pl. 15.

——, *1938*, Cretaceous species of *Gümbelina* and related genera, *Cushman Lab. Foram. Res., Contr.*, vol. 14, pt. 1, pp. 2–27, pls. 1–4.

——, *1938*, Additional new species of American Cretaceous Foraminifera, *Cushman Lab. Foram. Res., Contr.*, vol. 14, pt. 2, pp. 31–50, pl. 5–8.

EGGER, J. G., *1899*, Foraminiferen und Ostrakoden aus den Kreidemergeln der Oberbayerischen Alpen, *Bayer. Akad. Wiss. München, Abh.*, Cl. 2, vol. 21, 230 pp., 27 pls. München.

——, *1907*, Mikrofauna de Kreideschichten des westlichen bayerischen Waldes und des Gebietes um Regensburg, Nassauisch. Ver. Naturkunde, *Bericht.*, 20, pp. 1–75, pls. 1–9.

——, *1910*, Ostrakoden und Foraminiferen des Eybrunner Kreidemergels in der Umgebung von Regensburg, *Nat. Ver. Regensburg, Bericht.*, pp. 1–48, pls. 1–6.

EICHENBERG, W., *1933*, Foraminiferen aus dem Albien von Wenden am Mittellandkanal, 25, Die Foraminiferen der Unterkreide, *Niedersächs. geol. Ver. zu Hannover*, Jahresber., 25, pp. 1–32, 5 text figs., 8 pls.

——, *1933*, Foraminiferen aus dem Barrême von Wenden am Mittellandkanal, 25, Die Foraminiferen der Unterkreide, *Niedersächs. geol. Ver. zu Hannover*, Jahresber., 25, pp. 167–200, 7 pls.

——, *1934*, Foraminiferen aus dem Hauterive von Wenden am Mittellandkanal, Die Foraminiferen der Unterkreide: *Niedersächs. geol. Ver. zu Hannover*, Jahresber., 26, pp. 150–146, 8 pls.

——, *1935*, Foraminiferen aus dem Apt von Wenden am Mittellandkanal, Die Foraminiferen der Unterkreide, *Roemer-Mus., Hildesheim*, No. 37, 4. Folge, pp. 1–40, 7 pls.

FRANKE, A., *1925*, Die Foraminiferen der Pommerschen Kreide, *Geol. Pal. Instit. Univ. Griefswald, Abhandl.*, vol. 6, pp. 1–96, pls. 1–8.

——, *1928*, Die Foraminiferen der Oberen Kreide Nord- und Mitteldeutschlands, *Preuss. Geol. Landesanst, Abhandl.*, n. ser., vol. 111, pt. 3, pp. 1–207, pls. 1–18.

GALLOWAY, J. J., *1933*, *A Manual of Foraminifera*, The Principia Press, Bloomington, Indiana, 483 pp., 42 pls.

HERON-ALLEN, EDWARD and EARLAND, ARTHUR, *1910*, On the Recent and Fossil Foraminifera of the shore-sands of Selsey Bill, Sussex. 5. The Cretaceous Foraminifera, *Roy. Micr. Soc., Jour.*, pp. 401–426, pls. 6–11.

LALICKER, CECIL G., *1935*, New Cretaceous Textulariidae, *Cushman Lab. Foram. Res., Contr.*, vol. 11, pt. 1, pp. 1–13, pls. 1–2.

MORROW, A. L., *1934*, Foraminifera and Ostracoda from the Upper Cretaceous of Kansas, *Jour. Paleontology*, vol. 8, no. 2, pp. 186–205, pls. 29–31.

PLUMMER, HELEN JEANNE, *1931*, *Gaudryinella*, a new foraminiferal genus, *Amer. Midland Naturalist*, vol. 12, no. 9, pp. 341–342, 1 fig.

——, *1931*, Cretaceous Foraminifera in Texas, *Texas Univ. Bull.* 3101, pp. 109–203, pls. 8–15.

REUSS, A. E., *1845*, *Die Versteinerungen der Böhmischen Kreideformation*, Stuttgart, vol. 6.

——, *1851*, Die Foraminiferen und Entomostraceen des Kreidemergels von Lemberg, *Haidinger's Nat. Abhandl.*, vol. 4, pp. 17–52, pls. 2–6.

——, *1860*, Die Foraminiferen der westphalischen Kreideformation, *Akad. Wiss. Wien., Sitz.*, vol. 40, pp. 147–238, pls. 1–13.

——, *1863*, Die Foraminiferen des norddeutschen Hils und Gault, *Akad. Wiss. Wien., Sitz.*, vol. 46, pp. 5–100, 13 pls.

——, *1863*, Die Foraminiferen Familie der Lagenideen, *Akad. Wiss. Wien., Sitz.*, vol. 46, pp. 308–342, pls. 1–7.

——, *1873*, Die Foraminiferen, Bryozoen und Ostracoden des Pläners, in GEINITZ'S Das Elbthalgebirge in Sachsen, Theil 2, Der Mittlere und Obere Quadere., *Palaeontographica*, vol. 20, pt. 2, pp. 11–157, pls. 20–24.

SAMPLE, C. H., *1932*, *Cribratina*, a new genus of foraminifera from the Comanchean of Texas, *Amer. Midland Naturalist*, vol. 13, pp. 319–322, pl. 30.

SCHACKO, G., 1892, Foraminiferen und Ostracoden a. d. Kreide von Moltzow, *Archiv. d. Freunde d. Naturg. i. Mecklenburg, Güstrow.*

THOMAS, N. L., and RICE, E. M., *1927*, Changing characters in some Texas species of *Gümbelina*, *Jour. Paleontology*, vol. 1, no. 2, pp. 141–144.

MANUSCRIPT RECEIVED BY THE EDITOR FEBRUARY 7, 1939.

JOURNAL OF PALEONTOLOGY, VOL. 14, NO. 2, PP. 127–139, PLS. 20–21, MARCH, 1940

# RADIOLARIAN FAUNA OF THE CABALLOS FORMATION, MARATHON BASIN, TEXAS[1]

ESTHER ABERDEEN
Wellesley College, Wellesley, Mass.

ABSTRACT—This study embodies the systematic classification of the Radiolaria of the Devonian Caballos formation and an analysis of their structures in relation to depth of deposition. To this end, a review of the radiolarian literature in North America, method of study, a brief discussion of the physiology, test structures and the basis for classification of the Radiolaria are included. The Radiolaria herein described are remarkably well preserved, many specimens retaining silicified remnants of originally organic structures. Eighteen genera are discriminated and 24 new species are described. Certain features of the shells suggest a shallow habitat for the fauna.

IN 1917, Baker and Bowman reported Radiolaria from the Santiago chert phase of the Caballos novaculite in the Marathon basin. They published photomicrographs showing Radiolaria from this horizon. Subsequently other investigators (P. B. King, 1930 and L. G. Henbest, 1935) have corroborated the occurrence but have not published descriptions of Radiolaria.

A survey of the literature on American radiolarian deposits shows that Radiolaria have been described from one horizon in the Paleozoic and several in the Mesozoic and Cenozoic and have been reported, but not described, from many other horizons. Descriptions of Radiolaria from the following formations have been published: (1) Deepskill-Normanskill cherts, of Ordovician age (Ruedemann and Wilson, 1935); (2) Franciscan cherts, of Jurassic age (Hinde, 1894); (3) Milwood series in Manitoba, of Upper Cretaceous age (Rüst, 1892); (4) Calvert formation of Maryland, of Miocene age (Martin, 1904); (5) Barbadoes earth deposits, of Miocene age (Ehrenberg, 1875). Radiolaria have been reported, though not described, from the following horizons: (1) Ordovician cherts of Notre Dame Bay, Newfoundland (Sampson, 1923); (2) red cherts in limestone of late Devonian age on the headwaters of the Trinity River, California (Diller, 1913); (3) Leonard and Word formations of Permian age in the Marathon Basin (King, 1930); (4) Jurassic cherts of the Kanai peninsula (Martin and others, 1912); (5) Jurassic cherts in Oregon (Smith, 1916); (6) Mowry shale, of Upper Cretaceous age, in Wyoming (Rubey, 1929); (7) Arkansas novaculite and Big Fork chert, of probable Devonian age (Henbest, 1936); (8) radiolarian earth in the Eocene section of the Mt. Diablo area, California (Clark and Campbell, 1937). Apparently many radiolarian-bearing horizons are known in North America but little has been done toward describing the fauna.

The fauna described below was studied in thin sections cut from specimens of Santiago member of the Caballos novaculite collected from the hogbacks 1½ miles east of Marathon, Texas. The Caballos novaculite is generally regarded as Devonian in age. The Santiago member is composed of banded chert in which the banding is almost varvelike in appearance. Greenish gray bands of detritus-like material ¼ to ½ inch thick alternate with bands of clear chert. The Radiolaria seem to be most abundant in the greenish layers, and specimens described were found principally in these bands. Sections were ground thin enough to transmt light but left sufficiently thick as to show the tests in three dimensions, a procedure which is necessary for the identification of most species.

## PHYSIOLOGY AND TEST STUCTURE OF RADIOLARIA

A brief outline of the physiology and morphology of Radiolaria seems pertinent here.

[1] Part of a dissertation submitted at the University of Chicago in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

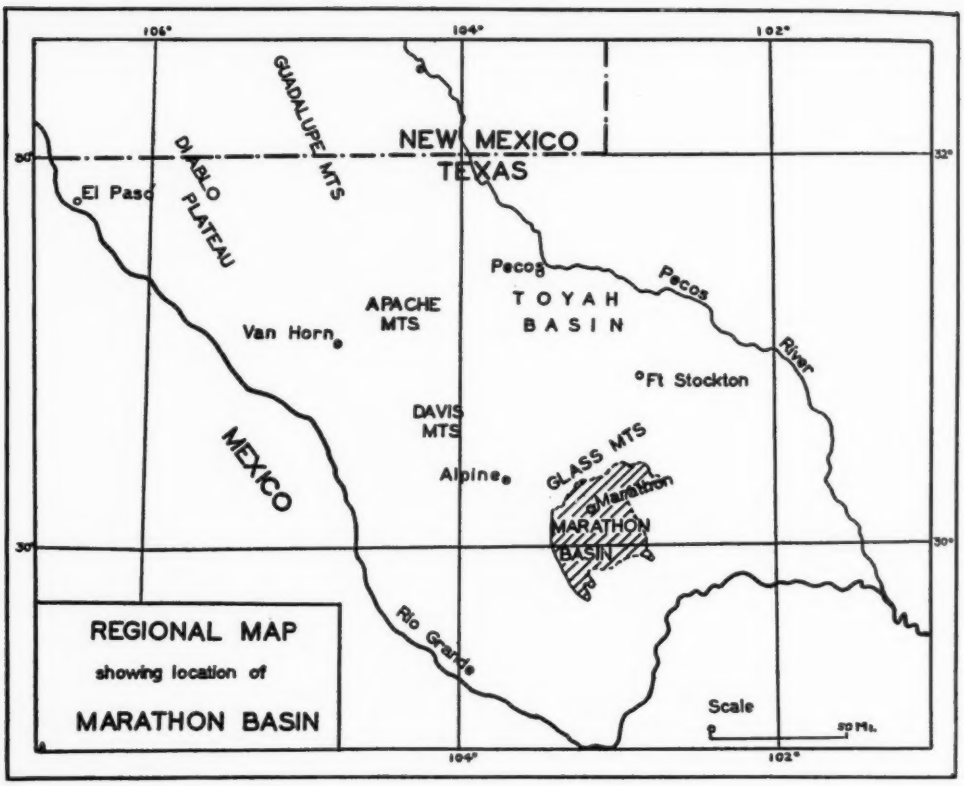



FIG. 1.—Sketch map showing location of the Marathon Basin, Texas (modified after King, 1937).

The cytoplasm of a radiolarian (Haeckel, 1887; Earland, 1900; Lankester, 1909) may be differentiated into three parts: (1) a cortical layer of cytoplasm (extracapsular cytoplasm), (2) an intracapsular nucleated cytoplasm, which is separated from the former by (3) a central capsule; the latter marks the division between these two layers and is the feature which distinguishes the Radiolaria from all other Protozoa.

The extracapsular cytoplasm consists of (a) a matrix or assimilative layer which lies immediately next to the central capsule, (b) a *calymma*, or vacuolated layer, frothy in appearance and chiefly flotational in function, and (c) an enveloping membrane, permeable in character, called the *sarcodictyum*. Through all of these extend radiating contractile pseudopodia, which arise in the matrix of the extracapsular layer outside the central capsule.

The central capsule is commonly a single, porous membrane, chitinoid, or mucinoid in character, although in one group, *Phaeodaria*, it may be double. Its shape reflects the configuration of the test of the animal. It may be considered a permanent structure, although it is thought to dissolve or rupture more or less during sporulation. It is perforated or contains varied apertures; these apertures (together with the shape and number of shells in the test) constitute one of the bases on which Radiolaria are classified.

The intracapsular cytoplasm is a vacuolated, granular mass, sometimes radially striated, in which are imbedded protein reserves, pigment cells, zooxanthellae (symbiotic protozoans), large crystalline structures and one or more nuclei. The whole is enveloped in a tough outer membrane (sarcodictyum), which serves to keep the vacu-

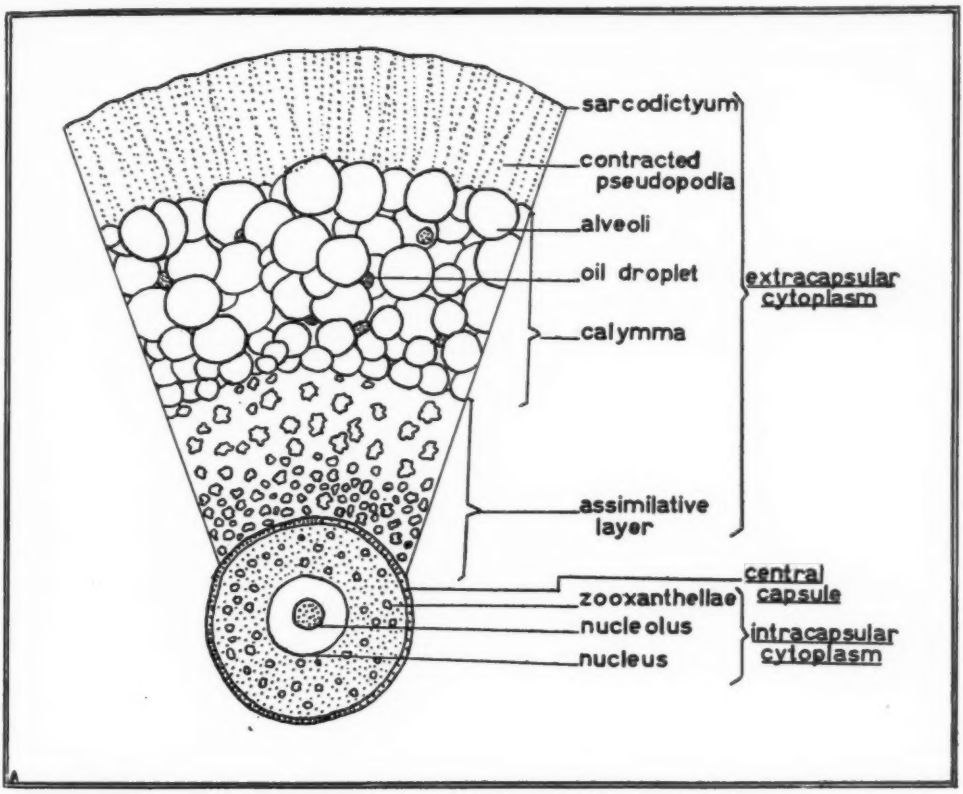



FIG. 2.—Generalized drawing of a radiolarian, showing relationship of various anatomical parts (after Haeckel, 1887).

oles of the calymma together and within the spicular skeletal area.

Each of these various anatomic divisions has its own physiological function. For example, the extracapsular cytoplasm is chiefly concerned with flotation, nutrition, and reception of stimuli. The intracapsular cytoplasm is given over to the process of storage and eventually to reproduction. The central capsule separates these two zones of differing activity.

Radiolarian tests, according to Haeckel, show a greater diversity of form than any other class of the animal kingdom. This diversity invites differentiation into many species. Myriads of forms, known and newly discovered during the Challenger expedition, were classified by Haeckel into the 739 genera and 4,217 species (Haeckel, 1887, p. clxxxviii).

It has been found that various tests are composed of different kinds of material, and shell composition is regarded as fundamental in classification. The same basic shapes may appear in tests composed of different materials. The *Acantharia* skeletons are made of strontium sulphate, the *Spumellaria* and *Nasellaria* of silica, and the *Phaeodaria* of silica combined with an organic compound.

Little is known concerning the formation of the radiolarian test other than that the vacuolated portion of the cytoplasm has the power to deposit silica in the form of perforated and imperforate shells, plates, processes and spicules. There commonly is a great development of siliceous matter, the form of which cannot be referred to the alveolate structures of the protoplasm. Some attempt has been made to trace

skeletal evolution in the *Acantharia* to an axopodial type developed by the hardening of the axial rod, a structure which is found only in the pseudopodia of this class. For other Radiolaria, it is suggested that the formation of the test occurs by fusion of tetrad spicules formed in the calymma by the deposition of silica at the junction of the alveoli. These hypotheses appear to be based on insufficient observational data (Lankester, 1901, p. 131).

The test functions chiefly as a hydrostatic organ. In the *Acanthametridia* it has been found that the spines serve as support for a delicate membrane (interpreted as the sarcodictyum) which confines the alveoli of the calymma (the flotational mechanism). In order to aid in flotation, the spines frequently are flattened or have flanges devised for sustaining and propelling the animal in positions most favorable for transportation in currents. Since these spines are used in classification, their variability adds considerably to the possible number of species.

Three kinds of structural variation are recognized in the tests of Radiolaria: (1) The variation of test structures characteristic of the species; (2) there is what Lankester calls racial somatic dimorphism, representing a response to depth environment in which a given genus or species may develop tests characteristic of deep water or shallow water; and, (3) finally there is a gametic dimorphism of early and adult stages related to reproduction, but such dimorphism has not been proven to result in somatic dimorphism of structure. These various types of dimorphism probably are partly responsible for the very large number of species which have been described.

The somatic dimorphism caused by varying depth environments results in the formation of widely diversified small individuals in warmer surface waters, and large individuals in cold and deep water. This difference in size is reflected in the structure of the test. The tests of the pelagic Radiolaria are delicate and slender, the pores are large, the trabeculae between the pores are thin, and the armature of the spines, such as spathylae and anchors, is diverse. Individuals of the abyssal fauna are characterized by small size and massive structures. Coarse lattice-work, thick trabeculae, small pores and less conspicuous spines are characteristic (Haeckel, 1887, pp. cliii and cliv).

*Paleontologic significance of anatomy and test structure.*—In the Radiolaria studied, certain anatomical parts appear to have been preserved. In thin section, a great many clear circles were observed, in reflected light, simply as bright spots. In reflected light these areas distinctly show the shadowy outline of the test, capsule and cloudy masses. In some instances a clear circular area is observed enveloping skeletal outlines, suggesting that the calymma might have been preserved despite its fragile character. Under ordinary circumstances, a gelatinous body of such character would not be preserved, and if our interpretations of these structures is correct the condition for preservation of soft parts must have been extraordinarily favorable. Silica gel and soft organic ooze collecting on a sea floor would probably be an ideal medium in which Radiolaria could settle without being fragmented. It is suggested that the calymma could be preserved under the following condition: The semipermeable membrane (Sarcodictyum) might allow silica rich waters to permeate the whole cytoplasm, and serve at the same time to exclude the organic ooze into which the animal settled. Photomicrographs of specimens oriented as found in the rock (pl. 1, figs. 1–3) show that the organic material settled and was compacted slightly around some specimens. The cytoplasm of the organism might thus become saturated with silica until the concentration within the organism equalled that of the surrounding medium at which point the whole might become solidified, thus preserving the soft organic structures. Evidence supporting this hypothesis is seen in some sections viewed under crossed nicols; the clear zones show coarse, radially-fibrous structures in contrast to the much finer fibrous structure of the matrix. The fact that some specimens do not show clear circles enveloping them suggests that those forms may have become partly disintegrated while settling through the water. Thus, it seems possible for some specimens to be preserved encased in their original gelatinous calymma whereas others are found without them.

The somatic response to depth reflected in dimorphism of test structure within one

genus is suggested as most valuable from the paleontological standpoint. Since the test structures of various species reflect the depth at which they float (thin and delicately spined forms for the surficial water, and thick, finely perforated, stout-spined forms for greater depth) the type of structure suggests the particular depth environment in which the species lived. Fossil fauna showing a mixture of both deep water forms and shallow water forms can be interpreted only as accumulating in deep waters; conversely, formations showing fauna entirely shallow water in their characteristics, can be interpreted as accumulating in shallow waters. Also surficial forms are more completely at the mercy of the surface currents than the deeper water species, and therefore may be floated into various environments.

*Caballos fauna.*—Eighteen genera are recognized in the Santiago chert, and 24 new species are described. Careful comparison with descriptions of European Paleozoic fauna yields no identical forms. The species *Stylosphaera quasiobtusa* n. sp. shows similarity to a species described by Hinde from the Tamworth series (Devonian) of Australia.

The Radiolaria of the Caballos formation are characterized by (a) slender, ridged or keeled spines, (b) large pores, (c) very thin connecting bars between the several shells of a test, and (d) delicately latticed shells. These characteristics in modern Radiolaria indicate shallow water not deeper than the pelagic zone.

Recently an attempt was made by Ruedemann to estimate the depth of deposition for the fossil Radiolaria from a study of depth ranges recorded for the same genera in modern seas (Ruedemann, 1935). He concluded that mixed fauna of shallow and deep water forms must have been deposited at depths no less than the greatest depth inhabited in life by the deep water forms. A similar comparison with modern forms has been made here in an attempt to secure information concerning depth of deposition for the Caballos formation. This study shows that almost every modern genus has both shallow and deep water species. In the fossil fauna four genera are represented by only surface dwelling species, and two genera are represented by only deep water species. These data might be interpreted to indicate that this fauna should be considered a deep water one, since it contains some genera found only in depths. But since great variation in depth range is found in modern species, interpretation of the environment for fossil species by analogy is not neces-

TABLE 1.—DEPTH RANGES FOR MODERN SPECIES WHOSE GENERA ARE REPRESENTED IN THE CABALLOS NOVACULITE[2]

| Genera present in Santiago chert | Author of Genus | Depth Range of Modern Species of same Genus |
|---|---|---|
| 1. *Cenosphaera* | Ehrenberg | Surface and depths to 2,750 fathoms |
| 2. *Carposphaera* | Haeckel | Surface and depths to 2,600 fathoms |
| 3. *Thecosphaera* | Haeckel | Surface (most species) and few at depths to 2,900 fathoms |
| 4. *Rhodosphaera* | Haeckel | 1 species, depth 2,900 fathoms |
| 5. *Plegmosphaera* | Haeckel | 8 species, all surface |
| 6. *Spongoplegma* | Haeckel | 1 species, 1,950 fathoms |
| 7. *Xiphostylus* | Haeckel | 15 species, 5 surface, others various depths to 4,475 fathoms |
| 8. *Stylosphaera* | Ehrenberg | 16 species, 3 fossil, 11 deep water and 5 surface |
| 9. *Staurosphaera* | Haeckel | 16 species, 1 fossil, 10 deep water to 3,000 fathoms, 1 surface |
| 10. *Staurostylus* | Haeckel | |
| 11. *Staurodoras* | Haeckel | 4 species, 3 fossil |
| 12. *Hexastylus* | Haeckel | 25 species, 9 surface, 16 deep water |
| 13. *Hexastylidium* | Haeckel | 2 species, surface |
| 14. *Hexalonche* | Haeckel | 25 species, 9 surface, 14 deep water to 4,500 fathoms, 2 fossil |
| 15. *Acanthosphaera* | Ehrenberg | 31 species, 15 surface, 14 deep water to 4,475 fathoms, 2 fossil |
| 16. *Heliosphaera* | Haeckel | 14 species known, 8 surface, 16 depths to 4,475 fathoms |
| 17. *Haliomma* | Ehrenberg | 33 species known, 19 surface, 11 depths to 2,900 fathoms, 3 fossil |
| 18. *Astrophacus* | Haeckel | 7 species known, 3 surface, 4 depths to 4,475 fathoms |

[2] Compiled from Haeckel, 1887.

sarily reliable. The best evidence of depth therefore appears to lie in structures of the test.

It is concluded that the Caballos radiolarian fauna may be considered a pelagic group, probably deposited in shallow waters, on the following lines of evidence: (1) their skeletal structures are typical of those forms indigenous to shallow waters; (2) the preservation of such structures of the calymma suggest rapid burial which might best be accomplished in waters of shallow depth, and in soft fine sediment of organic siliceous ooze.

*Acknowledgments.*—The writer is indebted to Dr. Carey Croneis for suggesting the study of the Caballos cherts, and for the interest, helpful criticism and suggestions given during the course of this study. The writer wishes to acknowledge the courtesy of Dr. C. L. Baker in furnishing samples of the formation studied. Acknowledgment is made to Mrs. Helen Jeanne Plummer for her cooperation in supplying references and samples of Barbadoes earth which served as a basis for preliminary studies. Dr. W. C. Krumbein of the University of Chicago and Dr. L. Sloss, Montana School of Mines gave invaluable assistance in the preparation of photomicrographs.

## SYSTEMATIC DESCRIPTIONS

In the classification of the modern Radiolaria, Ehrenberg's pioneer work, done chiefly on fossil forms, has been completely revised. In Haeckel's reports many of Ehrenberg's genera fall into groups based on biological features while others are discarded. Haeckel's classification is largely a biologic one, but genera and species are determined primarily by the structure of the test.

Following Haeckel's classification, the Class Radiolaria is distinguished from all other Sarcodina by the fact that it has a central capsule. Subclasses are established on features of the central capsule, its shape and position of apertures; i.e., forms having a spherical shape without an aperture are called Porulosa; and forms having an oval shape with an aperture at the basal pole are called Osculosa. The so-called Legions are determined (1) by the composition of the test in the Porulosa, those with siliceous tests being called Spumellaria, and those with strontium sulphate tests, the Acanthometrida; (2) in the Osculosa, Legions are determined by the type of closure for the aperture. A porous plate closes the aperture in Nasellaria, and an operculum and astropyle in the Phaeodaria. Sublegions of Haeckel are determined by the condition of the test: (1) incomplete or wanting, Collodaria; (2) complete or shell-bearing forms, Sphaerellaria. Orders are based on the shape of the test: (1) A test is wanting in the Colloidea; the Beloidea are composed of disarticulated spicules, (2) Sphaeroidea and Prunoidea and other orders are based on the general outline of the tests. Families are based on combinations of features such as (1) the number of shells and spines of an individual test; (2) position of various rings and number of constrictions, or (3) types of aperture. Genera and Species are based on a number of features such as (1) number, length, shape and terminae of spines, (2) presence or absence of spongy shell structures, and (3) their shape, size and distribution of pores.

Students of Radiolaria have generally adopted Haeckel's classifications. Only occasionally have subsequent workers found it necessary to establish new genera, and generally the method of description used for the living forms has been followed. Up to 1900, approximately 15 new fossil genera had been added to the list of genera known to Haeckel. Three were established by Rüst, one by Dryer and 11 by Hinde. This is a surprisingly small number of new genera considering the fact that the number of new species has been enormous.

All specimens described in this paper come from the same locality, hogbacks 1½ miles east of Marathon, Texas, and are from the Santiago chert member in the Caballos novaculite.

### SYSTEMATIC DESCRIPTIONS

### Class RADIOLARIA

### Legion SPUMELLARIA Ehrenberg, 1875

### Order COLLODARIA Haeckel, 1881

### Family THALLASSICOLLIDAE Haeckel, 1862

Plate 20, figures 1–3

Many specimens appearing as almost clear globules with only faint outlines of the central capsule are considered to be mem-

bers of this family. Usually the calymma is preserved outside the central capsule.

Order SPAERELLARIA Haeckel, 1881
Family LIOSPHAERIDAE Haeckel, 1881
Genus CENOSPHAERA Ehrenberg, 1854

Liosphaeridae with a single latticed sphere having simple pores (not prolonged in tubuli), and a simple shell cavity (without internal radial beams).

*Remarks.*—Species are based on shape and distribution of pores.

CENOSPHAERA VARIABILIS Aberdeen, n. sp.
Plate 20, figure 17

Test is simple, spherical lattice 0.145 mm in diameter, with lattice bars 0.027 mm in width; pores vary in size from 0.007 to 0.104 mm.

*Remarks.*—The range in pore size is marked but consistent in all specimens; the larger pores are about twice the size of the smaller ones.

*Types.*—Syntypes, Walker Mus., Chicago Univ. 44496, no. 2; 44997, no. 9.

CENOSPHAERA HEXAGONALIS
Aberdeen, n. sp.
Plate 20, figures 12, 13

Test simple, lattice 0.166 mm in diameter with very thin and delicate lattice bars 0.02 mm in diameter; pores large, 0.06 mm in diameter, and either hexagonal or polygonal in outline.

*Remarks.*—This species is characterized by polygonal or hexagonal pores, and very thin lattice bars. It is smaller than the average Radiolaria in this fauna. It is similar to, but larger than, *Cenosphaera regularis* Rüst, 1885 (Rüst, 1885, table 1, fig. 5).

*Type.*—Holotype, Walker Mus., Chicago Univ. 44496, no. 1.

CENOSPHAERA SEMIEQUALIS Aberdeen, n. sp.
Plate 20, figures 7, 8

Test simple, spherical lattice of large size with pores only slightly larger than the width of the lattice bars; diameter of test, 0.25 mm.; lattice bars 0.007 mm.; pores vary in size from 0.007 to 0.005 mm.

*Remarks.*—This species differs from *C. hexagonalis*, n. sp. in larger size of the test and shape of the pores; it differs from *C. variabilis*, n. sp. in size, although the pore arrangement in both is variable, the lattice bars are slightly thicker in *C. semiequalis*.

*Types.*—Syntypes, Walker Mus., Chicago Univ. 44538, no. 2; 44997, no. 9.

Family CARPOSPHAERIDAE Haeckel, 1881
Genus CARPOSPHAERA Haeckel, 1881

Test possesses one medullary (intracapsular) and one cortical (extracapsular) shell, both connected by radial beams piercing the central capsule.

*Remarks.*—The distance between shells is as great and commonly much greater than the radius of the inner shell. In *Liosphaera*, this distance is less than the radius of the inner shell.

CARPOSPHAERA MAGNA Aberdeen, n. sp.
Plate 20, figure 18; plate 21, figures 4, 10

Test consists of two lattice shells one within the other, connected by bars; inner shell separated from outer shell by a distance greater than radius of inner shell; diameter of test, 0.415 mm to 0.362 mm; thickness of outer shell, 0.0166 mm; diameter of inner shell, 0.099 mm; length of connecting bars, 0.133 mm; average number of connecting bars visible, eight.

*Remarks.*—This species is characterized by very small inner shells. The length of the connecting bars is correspondingly long. The test generally is large.

*Types.*—Syntypes, Walker Mus., Chicago Univ. 44493, no. 8; 44545, no. 8; 44535, no. 2.

CARPOSPHAERA EQUALIS Aberdeen, n. sp.
Plate 20, figures 4, 5

Test of two latticed shells, one within the other, connected by bars; inner shell separated from outer shell by a distance equal to diameter of inner shell; diameter of test, 0.282 mm to 0.362 mm; thickness of outer shell, 0.106 mm; diameter of inner shell, 0.083 to 0.11 mm; length of bars, about 0.09 mm.

*Remarks.*—The latticed shell in the center has pores 0.008 mm in diameter which are irregularly shaped. *C. equalis* differs from *C. magna* in its smaller size and larger inner sphere.

*Types.*—Syntypes, Walker Mus., Chicago Univ. 44545, no. 7; 44543, no. 4.

Family THECOSPHAERIDAE Haeckel, 1881
Genus THECOSPHAERA Haeckel, 1881

Test with two medullary (intracapsular) shells and one cortical (extracapsular) shell; distance between two inner shells less than between inner and outer shells.

THECOSPHAERA HEXPENETRATA
Aberdeen, n. sp.
Plate 21, figure 16

Test consists of three concentric latticed shells; inner two closely spaced, but are separated widely from the outer shell; bars in varying numbers extend from the outer shell to the first inner shell, but there are only six bars which penetrate from the outer shell into the central shell; diameter of test 0.39 mm; thickness of outer shell 0.06 mm; diameter of penultimate shell , 0.113 mm; diameter of innermost shell, 0.08 mm; thickness of bars, 0.026 mm.

*Remarks.*—This species differs from *T. sexarctica* Rüst (Rüst, 1891–92, p. 137) in that the latter has six bars which extend from the outer shell to the innermost shell. No other supporting bars are present.

*Type.*—Holotype, Walker Mus., Chicago Univ. 44536, no. 2.

Genus RHODOSPHAERA Haeckel, 1881

Thecosphaeridae with one medullary (intracapsular shell and two cortical (extracapsular) shells. *Rhodosphaera* differs from *Thecosphaera* in that the outer shells lie closer together. The distance between these two outer shells is much smaller than the radius of the inner shell. The inner shells are connected to the outer ones by radial bars.

RHODOSPHAERA sp. indet.
Plate 20, figure 10

The specimen referred to this genus shows three concentric shells; the inner separated from the two outer ones by a distance greater than the radius of the inner shell. The radial beams in the specimen described are indicated only between the inner shell and the second extracapsular shell.

*Type.*—Figured specimen, Walker Mus. Chicago Univ. 44547, no. 2.

Family PLEGMOSPHAERIDAE Haeckel, 1881
Genus PLEGMOSPHAERA Haeckel, 1881

Test consisting of hollow sphere of spongy framework without a medullary shell in the central cavity; wall composed of loose or dense spongy wicker-work; simple lattices may or may not be present as supports for the spongy framework either on inner or outer surface.

PLEGMOSPHAERA SPICULATA
Aberdeen, n. sp.
Plate 21, figure 3

Test consists of spherical shell of thick and spongy silica; outer rim of shell latticed, and separated from thicker inner spongy shell by numerous slender spicules; diameter of test, 0.498 mm; diameter of central space, 0.315 mm; inner surface of spongy framework finely porous; spicules are characteristic of the species.

*Type.*—Holotype, Walker Mus., Chicago Univ. 44532, no. 7; paratype, Walker Mus., Chicago Univ. 44497, no. 4.

Genus SPONGOPLEGMA Haeckel, 1881

Plegmosphaeridae is spongy framework enclosing in center a single latticed medullary shell.

SPONGOPLEGMA BREVISPHAERA
Aberdeen, n. sp.
Plate 21, figure 17

Test consists of spongy shell diameter of which is 0.5 mm; shell thickness, 0.08 mm; within spongy external shell is a central area, 0.30 mm; in the middle of which is small lattice sphere, 0.08 mm in diameter.

*Remarks.*—The spongy network is less than half as wide as in *S. longispina*. The thinner spongy shell characterizes the new species.

*Types.*—Syntypes, Walker Mus., Chicago Univ. 44543, no. 3; 44538, no. 1.

SPONGOPLEGMA LONGISPINOSA
Aberdeen, n. sp.
Plate 20, figure 6

Test consists of spongy external shell 0.68 mm in diameter, and 0.16 mm in thickness, within which is smaller lattice sphere 0.12 mm in diameter and 0.005 mm in thickness; bars 0.01 mm in diameter and 0.11 mm long

connect this inner sphere with the outer sphere.

*Remarks.*—Within the spongy shell long spines extend from the innermost spongy portion of the external shell to support the outer layer of spongy lattice, and are characteristic of this species.

*Types.*—Syntypes, Walker Mus., Chicago Univ. 44998, no. 13; 44546, no. 5.

Family STYLOSPHAERIDAE Haeckel, 1881
Genus XIPHOSTYLUS Haeckel, 1881

Test with one single lattice and two free spines of variable size and form.

*Remarks.*—This genus differs from *Xiphosphaera* in size and form of spines, which are equal in size in the latter.

XIPHOSTYLUS INCLINATUS Aberdeen, n. sp.
Plate 21, figures 7, 8

Test consists of single lattice sphere, 0.19 mm in diameter and 0.01 mm in thickness with two unequal spines opposite each other, shorter spine is 0.14 mm in length and 0.05 mm in width at the base; the longer spine is 0.19 mm in length and 0.06 mm in width at the base; lattice of shell has very minute uniform pores 0.004 mm in diameter.

*Remarks.*—This species differs from *X. asper* Rüst (Rüst, 1891–1892, pl. 7, fig. 6 and pl. 10, fig. 7) from the lower Silurian phosphorite of Cambriérè, in having longer spines. It differs from *X. ardea* Rüst from the lower Carboniferous in the Harz in that *X. ardea* has a group of spines.

*Types.*—Syntypes, Walker Mus., Chicago Univ. 44548, no. 1; 44494, no. 1.

Genus STYLOSPHAERA Ehrenberg, 1847

Stylosphaeridae with two concentric latticed spheres and two free spines of equal size and similar form. The two shells are connected by radial beams piercing the wall of the central capsule.

STYLOSPHAERA QUASIOBTUSA
Aberdeen, n. sp.
Plate 21, figure 5

Test consists of two concentric latticed spheres of which the outer one is 0.2 mm in diameter and 0.01 mm in thickness; the inner one, 0.08 mm in diameter, thickness undeterminable; two bars in line with the spines support the inner sphere respectively 0.05 mm in length and 0.01 mm in width; two stout spines opposite each other, equal in size and length extending from the surface of the outer sphere, have a length of 0.18 mm and width at the base of 0.05 mm.

*Remarks.*—*Stylosphaera* occurs in the Tamworth series (Devonian) of Australia. The species here described resembles *S. obtusa* Hinde from the Tamworth horizon (Hinde, 1899, p. 45), but differs from it in (1) shorter spines, (2) lattice sphere twice as large, and (3) thinner support for inner sphere.

*Types.*—Syntypes, Walker Mus., Chicago Univ. 44544, no. 5b; 44998, no. 2.

Family STAUROSPHAERIDAE Haeckel, 1881
Genus STAUROSTYLUS Haeckel, 1881

Tests are single latticed spheres with four spines in pairs of unequal length.

STAUROSTYLUS VARISPINATUS
Aberdeen, n. sp.
Plate 20, figure 19

Test consists of a single spherical shell (somewhat fractured in figured specimen) 0.20 mm in diameter and 0.006 mm in thickness; spines unequal in size and definitely keeled, probably paired; longer spine, 0.18 mm in length and 0.05 mm in width at base with pointed end; shorter spine, 0.07 mm in length and 0.04 mm broad at base with rounded end; latticed sphere seems to be evenly porous, pores being 0.01 mm in diameter.

*Type.*—Holotype, Walker Mus., Chicago Univ. 44997, no. 8.

Genus STAUROSPHAERA Haeckel, 1881

Staurosphaeridae with single latticed sphere and four equal spines lying in the same plane at right angles to each other.

STAUROSPHAERA ROTUNDA Aberdeen, n. sp.
Plate 20, figure 11

Test consisting of a single latticed sphere 0.16 mm in diameter and 0.005 mm in thickness; pores of test range in size from 0.004 mm to 0.013 mm; spines approximately 0.06 mm in length and are blunt.

*Remarks.*—The size of the latticed sphere is diagnostic. The bluntness of the spine suggests that they may have been longer, but the size compared with other *Staurosphaera* is smaller and more obviously rounded.

*Type.*—Holotype, Walker Mus., Chicago Univ. 44548, no. 5.

Genus STAURODORAS Haeckel, 1881

Staurosphaeridae with solid, spongy, spherical shells and four simple cortical spines.

STAURODORAS BREVISPINOSA
Aberdeen, n. sp.
Plate 21, figure 11

Test spongy, spherical, 0.12 mm in diameter; pores on the surface exceedingly minute, about 0.002 mm in diameter; thickness of shell undeterminable; four spines present, short, about 0.02 mm in length.

*Type.*—Holotype, Walker Mus., Chicago Univ. 44546, no. 6.

Family CUBOSPHAERIDAE Haeckel, 1881
Genus HEXASTYLUS Haeckel, 1881

Cubosphaeridae with one simple latticed shell and six simple, equal spines.

HEXASTYLUS BASIPOROSUS Aberdeen, n. sp.
Plate 21, figures 6, 9, 13

Test single latticed sphere, 0.09 mm in diameter and 0.01 mm thick with six spines of equal length; spines are 0.06 mm in length, 0.02 mm wide at the base, and have keels on four sides; latticed bars are 0.002 mm thick, and the pores vary from 0.004 mm to 0.02 mm in size. Larger pores seem to be arranged about the base of the spines; this feature characterizes the species.

*Types.*—Syntypes, Walker Mus., Chicago Univ., 44495, no. 2; 44546, no. 5a; 44549, no. 10; 44537, no. 2.

Genus HEXASTYLIDIUM Haeckel, 1881

Cubosphaeridae with one simple latticed sphere and three unequal pairs of spines; two opposite spines of each pair equal.

HEXASTYLIDIUM VARIATUM Aberdeen, n. sp.
Plate 21, figure 14

Test consisting of a single latticed shell,

---

EXPLANATION OF PLATE 20

All specimens illustrated are from the Caballos formation, Marathon, Texas; all figures ×93, except fig. 18, which is ×18.

FIGS. *1–3—Thallasicollidae*, family. *1*, Figured specimen, Walker Mus., Chicago Univ. 44544, no. 5. *2*, Figured specimen, Walker Mus., Chicago Univ. 44544, no. 4. *3*, Figured specimen, Walker Mus., Chicago, Univ. 44544. Specimens showing calymma preserved and compaction of organic ooze around organism. (p. 132)

*4, 5—Carposphaera equalis* Aberdeen, n. sp. *4*, Syntype, Walker Mus., Chicago, Univ. 44546, no. 8. *5*, Syntype, Walker Mus., Chicago Univ., 44532, no. 6. (p. 133)

*6—Spongoplegma longispinosa* Aberdeen, n. sp. Syntype, Walker Mus., Chicago Univ. 44546, no. 5. (p. 134)

*7, 8—Cenosphaera semiequalis* Aberdeen, n. sp. Syntype, Walker Mus., Chicago Univ. 44538, no. 2. *8*, Syntype, Walker Mus., Chicago Univ. 44998, no. 9. (p. 133)

*9—Hexalonche* sp. indet. Figured specimen, Walker Mus., Chicago Univ. 44997, no. 12. (p. 137)

*10—Rhodosphaera*, sp. indet. Figured specimen, Walker Mus., Chicago Univ. 44547, no. 2. (p. 134)

*11—Staurosphaera rotunda* Aberdeen, n. sp. Holotype, Walker Mus., Chicago Univ. 44548, no. 5. (p. 135)

*12, 13—Cenosphaera hexagonalis* Aberdeen, n. sp. Holotype, Walker Mus., Chicago Univ. 44496, no. 1. *13*, Paratype, Walker Mus., Chicago Univ. 44995, no. 5. (p. 133)

*14—Heliosphaera macrospinosa* Aberdeen, n. sp. Holotype, Walker Mus., Chicago Univ. 44498, no. 1. (p. 138)

*15—Astrophacus cingulatus* Aberdeen, n. sp. Holotype, Walker Mus., Chicago Univ. 44996, no. 4. (p. 139)

*16, 20—Haliomma perfecta* Aberdeen, n. sp. *16*, Syntype, Walker Mus., Chicago Univ. 44532, no. 6. *20*, Syntype, Walker Mus., Chicago Univ. 44546, no. 8. (p. 138)

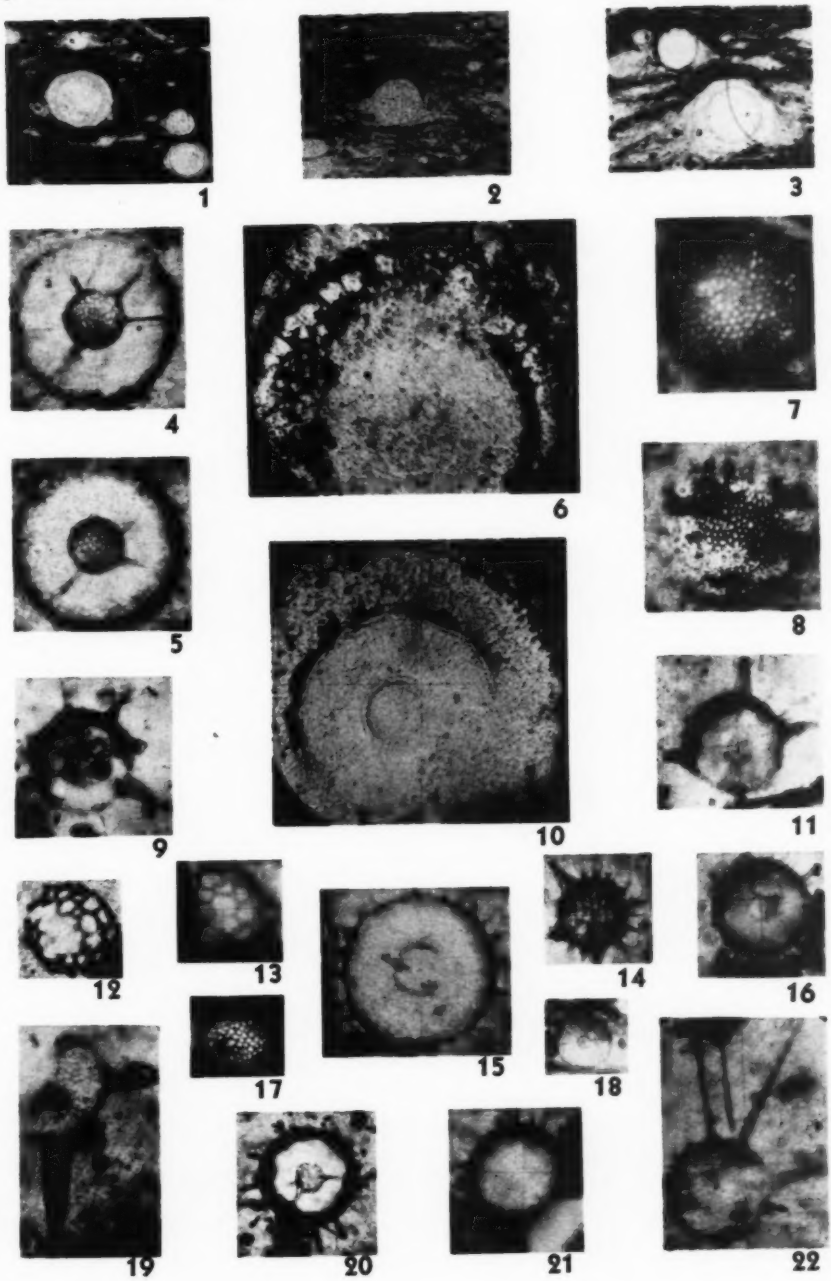
*17—Cenosphaera variabilis* Aberdeen, n. sp. Syntype, Walker Mus., Chicago Univ. 44496, no. 2. (p. 133)

*18—Carposphaera magna* Aberdeen, n. sp. Syntype, Walker Mus., Chicago Univ. 44493, no. 8. (p. 133)

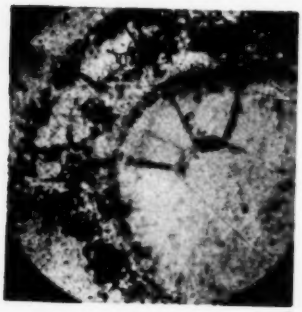
*19—Staurostylus varispinatus* Aberdeen, n. sp. Holotype, Walker Mus., Chicago Univ. 44997, no. 8c. (p. 135)

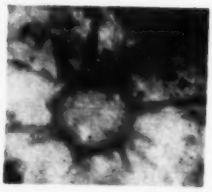
*21—Acanthosphaera microspinosa* Aberdeen, n. sp. Holotype, Walker Mus., Chicago Univ. 44534, no. 6. (p. 138)

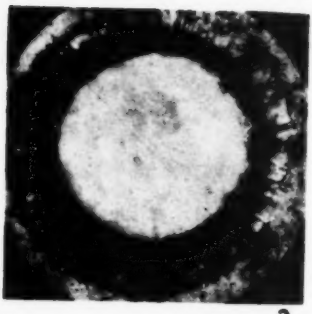
*22—Heliosphaera alternata* Aberdeen, n. sp. Holotype, Walker Mus., Chicago Univ. 44545, no. 7. (p. 138)

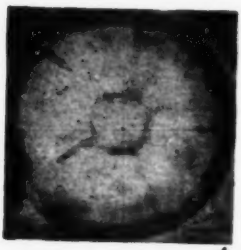


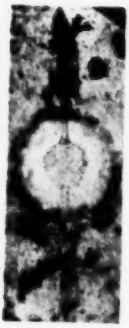

Aberdeen, Devonian Radiolaria

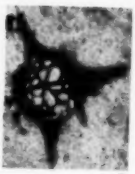

1


2


3

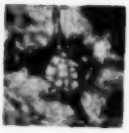

4


5


6

7

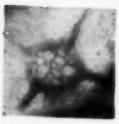
8

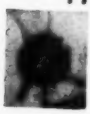

9

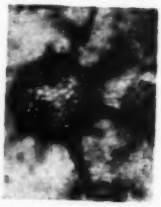
10

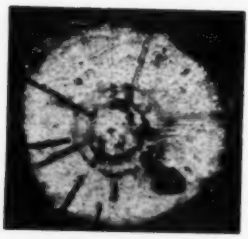
11

12

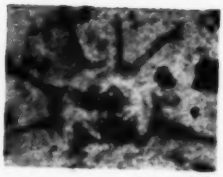

13

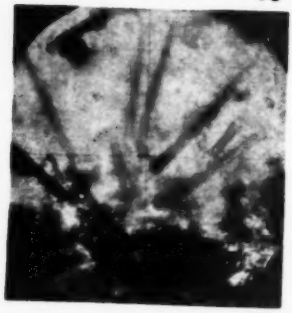

14


15


16

17


18


19

Aberdeen, Devonian Radiolaria

0.1 mm in diameter, coarsely porous, with three pairs of unequal spines; longer pair apparently represented by only one spine, which is thicker and longer than the others, being 0.14 mm in length and 0.016 mm in diameter; second pair of spines shorter, thicker and sharply pointed being 0.04 in length and 0.02 mm wide at the base; smaller spine very slender being 0.14 mm in length and 0.006 mm in width; lattice pores irregularly polygonal in shape varying from 0.115 mm to 0.01 mm.

*Type.*—Holotype, Walker Mus., Chicago Univ., 44545, no. 11.

### Genus HEXALONCHE Haeckel, 1881

Cubosphaeridae with two concentric shells and six simple spines of equal size.

#### HEXALONCHE sp. indet.
Plate 20, figure 9

Test consists of two concentric latticed spheres with three sets of paired spines; diameter of outer shell, 0.17 mm; thickness, 0.005 mm; diameter of inner shell, 0.14 mm; thickness, 0.002 mm; spines are 0.1 mm in length and 0.12 mm in width at the base; outer sphere finely perforated, pores about 0.007 mm in size.

*Types.*—Figured specimens, Walker Mus., Chicago Univ. 44997, no. 12; 44537, no. 6.

### Family ASTROSPHAERIDAE Haeckel, 1881
### Genus ACANTHOSPHAERA Ehrenberg, 1858

Test having one simple lattice sphere, covered with simple, uniform, radial spines.

#### ACANTHOSPHAERA DODECASPINOSA
Aberdeen, n. sp.
Plate 21, figures 2, 15, 18

Test consisting of single lattice sphere, 0.16 mm in diameter and 0.004 mm in thickness; 10 to 12 equal spines radiating from various points on the sphere having a length of 0.10 mm and width of 0.02 mm, and are slightly keeled at the base. Lattice shows rather small pores varying in size from 0.115 mm to 0.01 mm; no definite arrangement of pores is visible.

*Types.*—Syntypes, Walker Mus., Chicago Univ., 44535, nos. 3, 4; 44548, no. 11.

---

#### EXPLANATION OF PLATE 21

All specimens illustrated are from the Caballos formation, Marathon, Texas; all figures ×93.

FIGS. *1*—*Spongoplegma longispinosa* Aberdeen, n. sp. Syntype, Walker Mus., Chicago Univ. 44998, no. 13. (p. 134)

*2, 15, 18*—*Acanthosphaera dodecaspinosa* Aberdeen, n. sp. *2*, Syntype, Walker Mus., Chicago Univ. 44538, no. 4. *15*, Syntype, Walker Mus., Chicago Univ. 44548, no. 11, *18*, Syntype, Walker Mus., Chicago Univ. 44535, no. 3. (p. 137)

*3*—*Plegmosphaera spiculata* Aberdeen, n. sp. Holotype, Walker Mus., Chicago Univ. 44532, no. 7. (p. 134)

*4, 10*—*Carposphaera magna* Aberdeen, n. sp. *4*, Syntype, Walker Mus., Chicago Univ. 44545, no. 8. *10*, Syntype, Walker Mus., Chicago Univ. 44535, no. 2. (p. 133)

*5*—*Stylosphaera quasiobtusa* Aberdeen, n. sp. Syntype, Walker Mus., Chicago Univ. 44998, no. 2. (p. 135)

*6, 9, 13*—*Hexastylus basiporosus* Aberdeen, n. sp. *6*, Syntype, Walker Mus., Chicago Univ. 44546, no. 5a. *9*, Syntype, Walker Mus., Chicago Univ. 44542, no. 4a. *13*, Syntype, Walker Mus., Chicago Univ. 44495, no. 2. (p. 136)

*7, 8*—*Xiphostylus inclinatus* Aberdeen, n. sp. *7*, Syntype, Walker Mus., Chicago Univ. 44494, no. 11. *8*, Syntype, Walker Mus., Chicago Univ. 44548, no. 1. (p. 135)

*11*—*Staurodoras brevispinosa* Aberdeen, n. sp. Holotype, Walker Mus., Chicago Univ. 44546, no. 6. (p. 136)

*12*—*Acanthosphaera hirsuta* Aberdeen, n. sp. Holotype, Walker Mus., Chicago Univ. 44543, no. 5. (p. 138)

*14*—*Hexastylidium variatum* Aberdeen, n. sp. Holotype, Walker Mus., Chicago Univ. 44545, no. 11. (p. 136)

*16*—*Thecosphaera hexpenetrata* Aberdeen, n. sp. Holotype, Walker Mus., Chicago Univ. 44536, no. 2. (p. 134)

*17*—*Spongoplegma brevisphaera* Aberdeen, n. sp. Syntype, Walker Mus., Chicago Univ. 44542, no. 3. (p. 134)

*19*—*Acanthosphaera grandispinosa* Aberdeen, n. sp. Holotype, Walker Mus., Chicago Univ. 44547, no. 3. (p. 138)

ACANTHOSPHAERA MICROSPINOSA
Aberdeen, n. sp.
Plate 20, figure 21

Test consisting of single latticed sphere 0.18 mm in diameter and about 0.01 mm in thickness; surface covered with many very short, slender spines 0.102 mm to 0.03 mm in length, all of which are about 0.01 mm wide at the base. Lattice of the test is irregularly perforated, the pores being irregularly polygonal in shape, and varying from 0.01 mm to 0.004 mm in diameter.

*Type.*—Holotype, Walker Mus., Chicago Univ. 44535, no. 6.

ACANTHOSPHAERA HIRSUTA Aberdeen, n. sp.
Plate 21, figure 12

Test consisting of single latticed shell, 0.18 mm in diameter and about 0.006 mm in thickness; slender spines, 0.14 mm in length and ranging from 0.004 to 0.006 mm in diameter cover the surface of the sphere.

*Remarks.*—The numerous slender spines surrounding the test produce a hirsute appearance differentiating it from other species of *Acanthosphaera*.

*Type.*—Holotype, Walker Mus., Chicago Univ. 44543, no. 5.

ACANTHOSPHAERA GRANDISPINOSA
Aberdeen, n. sp.
Plate 21, figure 19

Test consisting of single latticed sphere, 0.2 mm in diameter; shell thickness and pore size undeterminable; long, tapering spines 0.24 mm in length and 0.02 mm in diameter are found over the surface. The unusual length of the spines is characteristic.

*Type.*—Holotype, Walker Mus., Chicago Univ. 44547, no. 3.

Genus HELIOSPHAERA Haeckel, 1862

Astrosphaeridae with one simple lattice sphere; covered with simple radial spines of two different kinds; larger spines separated by smaller spines.

HELIOSPHAERA MACROSPINOSA
Aberdeen, n. sp.
Plate 20, figure 14

Test a single latticed sphere, 0.12 mm in diameter and 0.01 mm in thickness; numerous spines of two sizes; larger spines are short, stout, sharp; 0.06 mm in length, and 0.03 mm in thickness at the bases; secondary spines about 0.04 mm in length and 0.01 mm in breadth; lattice coarse; pores about twice as wide as lattice bars; diameter varies from 0.01 mm to 0.02 mm.

*Remarks.*—The large stout spines and coarse lattice are characteristic of the species.

*Type.*—Holotype, Walker Mus., Chicago Univ. 44498, no. 1.

HELIOSPHAERA ALTERNATA
Aberdeen, n. sp.
Plate 20, figure 22

Test consisting of single latticed sphere 0.18 mm in diameter and 0.01 mm in thickness; there are two groups of spines present. The longer spines are long, slender tapering to a point being variable in number, 0.14 mm in length and about 0.12 mm in width at the base. They are separated by smaller short ones, 0.02 mm in length and about 0.001 mm in diameter; lattice pores are polygonal, varying in size from 0.002 mm to 0.01 mm in diameter; and are much larger than the thickness of the lattice bars.

*Type.*—Holotype, Walker Mus., Chicago Univ. 44545, no. 7.

Genus HALIOMMA Ehrenberg, 1838

Astrosphaeridae with one medullary (intracapsular) and one cortical (extracapsular) shell, which are connected by radial beams, piercing the central capsule. Shell surface covered with uniform simple radial spines of the same kind.

HALIOMMA PERFECTA Aberdeen, n. sp.
Plate 20, figures 4, 6, 20

Test consisting of two latticed concentric spheres of which the outer one is 0.18 mm to 0.20 mm in diameter, and about 0.01 mm in thickness; inner sphere about 0.04 mm in diameter and 0.001 mm in thickness being supported by six bars 0.005 mm in thickness and 0.05 mm long; spines short, about 0.02 mm to 0.03 mm in length and 0.002 mm in width at base; lattice pores of outer sphere about 0.01 mm in diameter, polygonal, about three times wider than the intervening areas; pores on inner shell undeterminable.

*Types.*—Syntypes, Walker Mus., Chi-

cago Univ. 44532, no. 6; 44537, no. 9; 44546, no. 8.

Order DISCOIDEA Haeckel, 1862
Family PHACODISCIDAE Haeckel, 1881
Genus ASTROPHACUS Haeckel, 1881

Phacodiscidae with double medullary shell and numerous (20 or more) simple radial spines on the margin of the disc, commonly with a variable number and an irregular disposition of the spines.

ASTROPHACUS CINGULATUS
Aberdeen, n. sp.
Plate 20, figure 15

Test consisting of two shells, the outer one being 0.32 mm in diameter and 0.005 mm in thickness. Apparently the center sphere was supported by bars, but only the remnant of one is visible. The even arrangement of the spines around the periphery and the exact number appearing on either side of the slide suggests that the outer shell was discoid in character with a spiny periphery. The spines are all 0.02 mm in length and 0.01 mm wide at the base. They are short and acuminate. No lattice is visible. The inner shell is spherical.

*Type.*—Holotype, Walker Mus., Chicago Univ. 44996, no. 4.

REFERENCES


BAKER, C. L., and BOWMAN, W. F., *1917*, Geologic exploration of the southeastern Front Range of Trans-Pecos, Texas: *Univ. Texas Bull.* 1753, pp. 93–101.

CLARK, B. L., and CAMPBELL, A. S., *1938*, Radiolarian earth in the Eocene series of Mt. Diablo area, middle California: *Geol. Soc. America Proc. 1937*, p. 74.

DILLER, J. S., *1903*, The Klamath mountain section, California: *Am. Jour. Sci.*, 4th ser., vol. 15, pp. 342–344.

——, *1896*, Geological reconnaissance in northwest Oregon: *U. S. Geol. Survey, 17th Ann. Rept.*, pt. 1, p. 470.

EHRENBERG, C. L., *1875*, *Fortsetzung der Microgeologischen Studien als gesammt Übersicht der mickroskopischer Paleontologie gleichartig analysicheter Gebirgsarten der Erde, mit specialler Rücksicht auf der Polycistinen-Mergel von Barbadoes*, Berlin.

HAECKEL, ERNEST, *1887*, The Radiolaria: *Challenger Expedition Reports*, vol. 18, pts. 1 and 2.

HENBEST, L. B., *1936*, Radiolaria in the Arkansas novaculite, Caballos novaculite, and Bigfork chert: *Jour. Paleontology*, vol. 10, pp. 76–78.

HINDE, G. J., *1894*, Note on radiolarian cherts from Angel Island, California: *California Univ., Dept. Geol. Sci., Bull.*, vol. 1, pp. 235–240.

——, *1899*, On the radiolaria in the Devonian rocks of New South Wales: *Geol. Soc. London Quart. Jour.*, vol. 40, pp. 38–50.

JUKES-BROWNE, A. J., and HARRISON, J. B., The geology of the Barbadoes: *Geol. Soc. London Quart. Jour.*, vol. 47, p. 197.

KING, P. B., *1930*, Geology of the Glass Mountains: *Texas Univ. Bull.* 3038, p. 64.

——, *1937*, Geology of the Marathon Region, Texas; *U. S. Geol. Survey Prof. Paper* 187.

LANKESTER, E. R., *1909*, *Treatise on Zoology:* pt. 1, fasc. 1, A. C. Black, London.

MARTIN, C. D., JOHNSON, B. L., and GRANT, U. S., *1912*, Geology and mineral resources of the Kenai peninsula, Alaska: *U. S. Geol. Survey Bull.* 587, p. 61.

MARTIN, G. C., *1904*, Radiolaria: *Maryland Geol. Survey, Miocene*, pp. 447, 459; pls. 130, 72–77.

RUBEY, G. C., *1929*, Origin of the siliceous Mowry shale of Black Hills region: *U. S. Geol. Survey Prof. Paper* 154-D, pp. 154–179.

RUEDEMANN, R., and WILSON, T. Y., *1936*, Eastern New York Ordovician cherts: *Geol. Soc. America Bull.*, vol. 47, pp. 1535–1586.

RÜST, R. D., *1884–85*, Beiträge zur Kenntniss der fossilen Radiolarien aus Gesteinen des Jura: *Paleontographica*, vol. 31, tab. 1, fig. 5.

——, *1892*, Radiolaria from the Pierre formation of northwestern Manitoba: *Canadian Geol. Survey, Contributions to Micropaleontology*, pt. iv, pp. 101–111.

——, *1891–1892*, Beiträge zur Kenntniss der fossilen Radiolarien aus Gesteinen der Trias und der Paleozoischen Schichten: *Paleontographica*, vol. 38, pl. 9, fig. 6, and pl. 10, fig. 7.

SAMPSON, E., *1923*, The ferruginous chert formations of Notre Dame Bay, Newfoundland: *Jour. Geology*, vol. 31, pp. 571–598.

SMITH, W. D., *1916*, Notes on radiolarian chert in Oregon: *Am. Jour. Sci.*, 4th ser., vol. 42, pp. 299–300; p. 504.

TYRELL, J. B., *1890*, Foraminifera and Radiolaria from the Cretaceous of Manitoba: *Royal Soc. Canada Trans.*, vol. 8, pp. 111–115.


MANUSCRIPT RECEIVED BY EDITOR MARCH, 15, 1939.

JOURNAL OF PALEONTOLOGY, VOL. 14, NO. 2, PP. 140–149, PLS. 22–23, MARCH, 1940

# HELICOPRION IN THE PERMIAN OF WESTERN AUSTRALIA

CURT TEICHERT
University of Western Australia, Crawley, Western Australia

ABSTRACT—New finds of *Helicoprion* in Western Australia led to a restudy and redefinition of the species *Edestus davisii*, described by Woodward in 1886. This species has always played an important role in discussions concerning the age and correlation of the "Permo-Carboniferous" sequence of Australia. The distribution, nature, habitat, and taxonomy of *Helicoprion* are reviewed and the significance of the genus for the correlation of the Western Australian sequence is discussed. Its occurrence in beds near the top of the marine Permo-Carboniferous of Western Australia forms an additional reason for the inclusion of these strata in the Artinskian. The Western Australian finds are described in detail, and it is found that *H. davisii* is even more closely allied to the genotype, *H. bessonowi*, than Karpinsky realized. Also, the internal structure of the Western Australian species is identical with the structure of *H. bessonowi* as described by Karpinsky.

EVER SINCE H. Woodward in 1886 described the remains of an Edestid from Western Australia, the probable occurrence of *Helicoprion* in this part of the world has aroused considerable attention and discussion, particularly in recent years in connection with attempts to correlate the "Permo-Carboniferous" of Australia with strata in other parts of the world (Schuchert, 1928; David and Sussmilch, 1931; Raggatt and Fletcher, 1937—to mention only the more recent contributions).

Woodward's original specimen which was described as *Edestus davisii*, came from the valley of the Arthur River, which enters the Gascoyne River some 130 miles inland from Carnarvon. It had not been found *in situ* and its source of origin was and still is a matter of speculation. This specimen is a beautifully preserved external mould of which a cast is here refigured (pl. 23, fig. 1). But, as will be seen from this illustration the specimen is fragmentary and its exact relationships have always been a matter of controversy, although the species has been mentioned and discussed in many articles by European, American, and Australian writers.

When establishing his new genus *Helicoprion*, Karpinsky in 1899 pointed out that at that time *Edestus davisii* was the only known species of Edestids which was sufficiently similar to the genotype of *Helicoprion*, *H. bessonowi*, to be included with it in the same genus, a view which was maintained by Karpinsky throughout his later writings on *Helicoprion*.

Eastman, however, in 1902 referred the Australian species to his genus *Campyloprion*, which is only poorly defined and most probably a synonym of *Helicoprion* (Karpinsky, 1912, p. 86), whereas Hay in 1909 included it in *Toxoprion*, a genus of Edestids with a curved row of teeth. In spite of these differences of opinion, Karpinsky (1912, p. 90) maintained that "*Edestus Davisii* is a spiral organ—a conjecture, that, we may hope, will be confirmed by future discoveries." Other authors followed this view more or less confidently, though the possibility that the West Australian form might belong to *Toxoprion* was never excluded from later discussions (David 1928, David and Sussmilch 1931, Raggatt and Fletcher 1937). David in 1928 gave an important account of *Edestus davisii* and of some of the views expressed on this species. He was inclined to regard the Australian form as more nearly allied to *Helicoprion* than to *Toxoprion*. The questions involved in the study of this fossil were clearly set out by David and Sussmilch in 1931 (p. 513) as follows:

> This occurrence of *Helicoprion* (?) is obviously of vital importance for the whole palaeontology and stratigraphy of the "Permo-Carboniferous" rocks of Australia, and every effort should be made to discover the exact horizon of its occurrence and to ascertain whether it had a spiral,

like *Helicoprion*, or resembled *Toxoprion*, or some allied Upper Carboniferous form.

Both these questions can now be answered with some degree of certainty: *Edestus davisii* is, in some respects, even more similar to *Helicoprion bessonowi* than Karpinsky realized, and the species occurs in the top part of the Wandagee stage, near the top of the marine Permian sequence of Western Australia.

## NEW OCCURRENCES OF HELICOPRION

No additional material of *Helicoprion* came to light during a period of 51 years after Woodward's description of *Edestus davisii*, until 1937 when Miss Shirley Gooch of Wandagee Station, Carnarvon District, found a row of five teeth belonging to the same species in the bed of the Minilya River, near Wandagee Homestead. Unfortunately, this specimen was not found *in situ* either, but it established the occurrence of the species in a region 120 miles north of the area where it was first discovered. Furthermore, in this specimen, the teeth are well preserved and their structure can be studied (plate 22, figures 2–4). The specimen, however, did not contribute towards establishing the relationships of *Edestus davisii*.

FIG. 1.—Map of Western Australia showing localities where *Helicoprion* has been found. 1, holotype no. 9080; 2, second specimen no. G 8523; 3, third specimen no. 19221.

Fortunately, a third specimen, which was found in May 1939, lends support to Karpinsky's view that *Edestus davisii* must be referred to *Helicoprion*. During a joint excursion with the writer on that part of the country south of the Minilya River which is known as Coolkilya Flat, about one mile north of Wandagee Hill, Mr. H. Coley picked up an external mould of a *Helicoprion*, and a few yards from this place Mr. E. P. Utting found part of the mould of the opposite side of the same specimen (pl. 23). These specimens were found in strata very close to the top of the Permo-Carboniferous sequence of the Northwest District.

Raggatt and others have subdivided the Permo-Carboniferous of the Northwestern part of Western Australia as follows (Raggatt 1936):

Wandagee Stage
Kennedy Stage
Byro Stage
Wooramel Stage
Callytharra Stage
Lyons Stage

Recent field work by the present writer and students of the University of Western Australia has resulted in the following subdivision of the Wandagee Stage (Teichert 1939a):

*Helicoprion-Fenestella* beds
*Lamellibranch* beds
*Calceolispongia-Strophalosia* beds
*Calceolispongia-Aulosteges* beds
*Lingula* beds

The thickness of the entire Wandagee "stage" is in the vicinity of 2,000 feet. *Helicoprion* was found in the lower part of the *Helicoprion-Fenestella* beds.

## FOREIGN DISTRIBUTION OF HELICOPRION

The more important facts in regard to the discovery and distribution of *Heli-*

*coprion* in different parts of the world have been presented in a recent paper by Wheeler (1939). The salient facts may be summarized here with a few additions and corrections to Wheeler's paper. Representatives of the genus are at present known from Russia, Japan, Indo-China, and western North America.

*Russia:* Karpinsky in 1899 announced the first finds of *Helicoprion* and described *Helicoprion bessonowi* from beds of Artinskian age in the Ural Mountains. In 1922, Karpinsky described another species, *Helicoprion ivanovi*, from the *Omphalotrochus* beds of the Uralian of the Ural Mountains. A find of Artinskian age, described as *Helicoprion clerci* by Karpinsky in 1916, was later transferred to a different genus, *Parahelicoprion*, by the same author (1922, 1925).

*Japan:* In 1903, Yabe reported *Helicoprian bessonowi* from the *Fusulina* limestone near Hanawa on the Waterasegawa River in Japan, where it occurs together with *Neoschwagerina*.

*Indo-China:* Hoffet in 1933 listed *Helicoprion* from the Houei Nam Cham limestone in the province of Laos. This limestone conformably overlies beds of Upper Uralian age.

*North America:* Wheeler in 1939 described two species of *Helicoprion*, one from Nevada, the other from California, both from formations of long-supposed Mesozoic age which are now classified as Upper Palaeozoic. If, as is probable, *Lissoprion*, Hay (1909) is a synonym of *Helicoprion* as maintained by Karpinsky (1912), though rejected by Hay (1929, p. 573), the genus is represented by *Lissoprion ferrieri* Hay in the Phosphoria formation of Idaho and Wyoming, whose cephalopod fauna is of Artinskian affinities (Miller and Cline, 1934, p. 287).

The occurrence of *Helicoprion* in the Upper Productus limestone of the Salt Range India was reported by Koken in 1901 and was applied in correlation by Koken in 1907, by Schuchert in 1928 and by others. It still is quoted by Wheeler (p. 104), although Branson in 1935 has shown that the Upper Productus limestone specimens belong to a different genus, *Helicampodus*, which has a straight, not a coiled, row of teeth. It seems, therefore, that *Helicoprion* is not represented in the Salt Range and does not, as Wheeler believes, help to substantiate Grabau's correlation of the Upper Productus limestone with the Artinskian and lower Kungurian.

With regard to the age of *Helicroprion* in different parts of the world the following facts are important:

In Russia, two different species occur in the Uralian and in the Artinskian. In Japan and in Indo-China the genus does not occur before the Artinskian. In America, one species of *Helicoprion* occurs in the Artinskian Phosphoria formation, others in strata which have been correlated with the help of this genus and cannot be used in intercontinental correlation.

### SIGNIFICANCE OF AUSTRALIAN HELICOPRION

Clarke indicated (1938) that there might be a great thickness of beds of Artinskian age in Western Australia and it has recently been suggested by the present writer (1939b), on the basis of general palaeontological evidence, that no marine strata younger than Artinskian in age are represented in the Permo-Carboniferous sequence of the Northwest Division of Western Australia. This statement is substantiated by the find of *Helicoprion* near the top of the Wandagee beds. Unfortunately, the exact place of the Wandagee beds in the stratigraphical sequence is not yet established beyond doubt. Results of recent fieldwork by the writer in 1939 seem to make it possible that the Wandagee beds are older than the Kennedy sandstone and correspond, in part, to the upper portion of the Byro beds of geologists who have studied the geological sections along the Gascoyne and the Wooramel Rivers. Thus, it cannot yet be said with certainty whether or not the Kennedy sandstone is to be included in the Artinskian series of Western Australia.

As regards the holotype of *Helicoprion davisii*, Raggatt hazards the guess that it might come from beds of Byro age (Raggatt and Fletcher 1937, p. 181) which is undoubtedly the best suggestion to be made under the circumstances as no strata younger than Byro are known to crop out in the general area from which the specimen must be derived (Raggatt 1936, Waterford). The

second specimen of *H. davisii*, mentioned above, from a locality near Wandagee Homestead, was found in a place which suggests derivation from a horizon somewhere below the Wandagee stage, perhaps from the lower part of the Byro, though the geology of the country east of Wandagee Homestead and further up the Minilya River is too poorly known to allow definite statements in this respect. There is thus the possibility that *Helicoprion* in Western Australia occurs at two different stratigraphic levels. On the other hand, it is possible that outcrops of Wandagee beds occur in places now mapped as undifferentiated Byro, but in any case the occurrence of the genus in Wandagee strata helps to fix an upper age limit for the correlation of the marine sequence in the Northwest Division of Western Australia.

## TAXONOMY OF HELICOPRION

The relationships of *Helicoprion* to the shark group were well established by Karpinsky in 1899. The genus was originally referred to the family Edestidae Jaekel by Karpinsky, and many later authors, including White (1936) and Wheeler (1939), followed Karpinsky's original suggestion, though Karpinsky himself in later papers (1911; 1912, p. 81) established a separate family Helicoprionidae which was also accepted by Hay in 1929. Romer (1933) referred *Edestus* and *Helicoprion* to the family *Heterodontidae*, and White, in 1936, established a separate suborder Edestida for the family Edestidae, including *Edestus* and *Helicoprion*. The following is a tabulated review of recent attempts to classify the genus *Helicoprion:*

Hay, 1929:

Superorder ARISTOSELACHII
Order SELACHII
Suborder SQUALIFORMES
Superfamily EDESTOIDEA
Family HELICOPRIONIDAE
Genus HELICOPRION

Romer, 1933:

Order ELASMOBRANCHII
Suborder SELACHII
Superfamily HETERODONTOIDEA
Family HETERODONTIDAE
Genus HELICOPRION

White, 1936:

Superorder ANTACEAE
Order HETERODONTEA
Suborder EDESTIDA
Superfamily EDESTOIDEA
Family EDESTIDAE
Genus HELICOPRION

Finally, Nielsen, in 1932 (p. 20) suggested that on account of the dentition and micro-structure of the teeth of the least specialized genera of the Edestidae (viz. *Agassizodus* and *Fadenia*), the Edestidae, including *Helicoprion*, should be included in the order Bradyodonti. The structure of the teeth of *Helicoprion*, however, is so different that, however true Nielsen's deductions may be in the case of the genera studied by him, they are hardly applicable to this genus. It seems justifiable to maintain the family Helicoprionidae in view of the important differences, mainly in the orientaton of the teeth, between *Edestus* and *Helicoprion*, which were pointed out by Hay in 1912 and by Karpinsky in 1911, 1912, and 1916.

In addition to *Helicoprion*, with its synonyms *Lissoprion* Hay and *Campyloprion* Eastman, this family includes *Parahelicoprion* Karpinsky.

## NATURE AND HABITAT OF HELICOPRION

Karpinsky's elaborate description of the structure of *Helicoprion*, published in 1899, is still unsurpassed. It went to prove that the segments or teeth of *Helicoprion* have a composition characteristic of elasmobranch teeth and placoid scales, and it is interesting to note that one of the recently discovered West Australian specimens of *Helicoprion davisii* is the first specimen from anywhere outside Russia in which the structure of the teeth can be studied and that this structure was found to be in full agreement with that found by Karpinsky in *Helicoprion bessonowi.*

Ever since its discovery there has been much speculation as to where the spiral of *Helicoprion* could have been situated in the living animal. Karpinsky, in his first monograph, discussed these alternatives, that the spiral might have formed part of the tail of the animal, or that it might have belonged to the mouth region in which case it must have projected from the mouth as a coiled

row of symphysial teeth. The first alternative, as well as later suggestions put forward by Eastman (1902), Fuchs (1900), Klaatsch (1901), Hay (1909) and others, were dismissed after Hay's description, in 1912, of a find of *Edestus* teeth in their natural position as symphysial teeth in both the upper and lower jaw. The matter was fully reviewed by Karpinsky in 1915 who was then fully convinced that the spiral of *Helicoprion* represented a symphysial row of teeth, arranged, for the most part, outside the

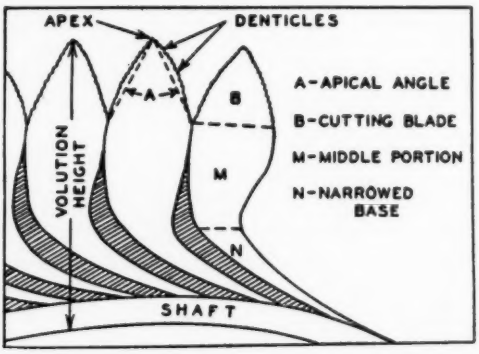



FIG. 2.—Morphological terminology of *Helicoprion*. (Adapted from Wheeler, 1939.)

mouth. He left open the question whether such a symphysial row had been present in both jaws or in only one, and, if so, whether in the upper or lower jaw. Even today, no answer to these questions can be given,and no better statement of the case can be given than those presented by Karpinsky in 1899 and 1915.

Karpinsky, as he explained especially in his paper in 1915, was of the opinion that *Helicoprion* was an animal of the high sea which only occasionally approached the coast. The symphysial teeth could only be preserved in a fossil state if the animal died near the coast or if it lost the spiral by violence during a fight near the coast. The latter must have been a very rare case, for, as Karpinsky pointed out, a fish of the size of *Helicoprion* can hardly have had any enemies in the littoral regions of the Artinskian sea in the Ural region. The same is true for Western Australia where the Artinskian fauna associated with *Helicoprion* in a general way, is very similar to that of the Urals, except for a smaller contingent of pelagic cephalopods. Brachiopods, lamellibranchs, and bryozoans are preponderating; there is a fair number of species of corals, of mostly benthonic gastropods, and of crinoids, whereas trilobites and ammonoids are rare. The last mentioned group is represented by species of *Propinacoceras* and *Paragastrioceras*.

### MORPHOLOGICAL TERMINOLOGY

For descriptive purposes the morphologic terminology proposed by Wheeler (1939, p. 109) can be accepted with the exception of the term "interdental spaces" which seems rather objectionable, though it was also used by Hay in 1909. Karpinsky's investigations have shown that the spiral of *Helicoprion* forms one solid structure, a fact which was overlooked by Klaatsch (1901) and others. What for descriptive purposes are called the "teeth" are actually the enamel-covered portions of the spiral. Two adjacent enamel-covered areas are separated by a curved depression which is not covered by enamel. Karpinsky did not apply a special term to these parts of the spiral, but referred to them as "nicht von Email bedeckten *Zwischenstreifen*" (1899, p. 396). That these "Zwischenstreifen" do not represent "interdental spaces" can be clearly seen by comparing figures 2 and 3 on plate 22 of *Helicoprion davisii*. In figure 3 the curved "Zwischenstreifen," plainly visible in figure 2, can be seen as depressions in the lower part of the dentine of the spiral.

---

### EXPLANATION OF PLATE 22

FIGS. *1–4*—*Helicoprion davisii* (Woodward). *1*, plaster cast of holotype (no. 9080 Western Australian Museum and Art Gallery); Arthur River, Carnarvon District, West Australia, nat. size; *2–4*, no. G 8523, Western Australian Museum and Art Gallery, Minilya River near Wandagee Homestead, Carnarvon District, Western Australia; *2*, side view, nat. size; *3*, end view, ×3; *4*, coronal view of first three teeth, ×3. (p. 145)

3



2



1



4

Teichert, Australian Helicoprion

UNIV. OF MICH.

## SYSTEMATIC DESCRIPTION

### HELICOPRION DAVISII (Woodward)

Plate 22, figures 1–4; plate 23, figures 1–4

*First specimen* (holotype, no. 9080, Museum and Art Gallery, Perth): Woodward's original specimen is a well preserved external mould which has been well described by that author and also by Karpinsky in 1899 (pp. 440–443). As no photographic reproduction of this specimen has ever been published, it is here figured on plate 22, figure 1. As Karpinsky observed, it represents more than one third of a volution, more exactly a sector of 156°, and it consists of 15 teeth and part of a sixteenth. The total number of the teeth in one entire volution must have been between 34 and 35. Karpinsky (1899, p. 441) calculated the number of teeth in one volution as 33, which, however, is somewhat too small. Measurements of some of the teeth are given in table 1. The edges of the blades are serrated and show on an average about 15 denticles on each side. Further particulars of this specimen will be discussed below in connection with the description of more recent finds.

*Second specimen* (no. G 8523, Museum and Art Gallery, Perth) (pl. 22, figs. 2–4): This is a row of five teeth which are well preserved except for the upper portions of the blades. Measurements are given on table 1. The uppermost parts of four of the blades are broken off along an uneven surface; the central tooth, however, is evenly rounded above with a shining surface (see pl. 22, fig. 4). It is hard to say whether this surface results from natural wear or has been produced by transport of the specimen in the river bed.

In this specimen the internal structure of the spiral can be studied and it was found that this structure apparently is in complete agreement with that of *Helicoprion bessonowi* as described by Karpinsky in 1899 and 1915. Since it was thought that the specimen would not furnish any essentially new information, no detailed histological study of it has been made which would have necessitated the destruction by sectioning of this unique find.

TABLE 1.—DIMENSIONS OF THE TEETH OF HELICOPRION DAVISII AND HELICOPRION BESSONOWI.

| | B | M | a | $\frac{a}{B}$ | $\frac{a}{B+M}$ | N | $\frac{B+M}{N}$ | sh | $\frac{sh}{a}$ |
|---|---|---|---|---|---|---|---|---|---|
| *Helicoprion davisii* | | | | | | | | | |
| (1) holotype: | | | | | | | | | |
| smallest tooth | 9.9 | 5.6 | 23.1 | 2.3 | 1.5 | 14.6 | 1.1 | 3.3 | 0.14 |
| 12th tooth | 13.6 | 8.3 | 30.5 | 2.2 | 1.4 | 21.4 | 1.0 | 3.7 | 0.12 |
| biggest tooth | 15.2 | 9.3 | 35.0 | 2.3 | 1.4 | 22.0 | 1.1 | 5.0 | 0.13 |
| (2) Second specimen (no. G 8523) | | | | | | | | | |
| middle tooth | 13.6 | 8.6 | 31.5 | 2.3 | 1.4 | 19.4 | 1.1 | 4.0 | 0.13 |
| (3) Third specimen (no. 19221) | | | | | | | | | |
| at ½ volution | 4.2 | 2.6 | 9.2 | 2.2 | 1.4 | 5.7 | 1.2 | 1.0 | 0.11 |
| at 1 volution | 5.3 | 2.8 | 11.2 | 2.1 | 1.4 | 6.7 | 1.2 | 1.7 | 0.15 |
| at 2 volutions | 9.3 | 6.4 | 22.4 | 2.4 | 1.4 | 15.9 | 1.0 | 3.0 | 0.13 |
| *Helicoprion bessonowi* Holotype (Karpinsky, 1899, Plate I) | | | | | | | | | |
| at 1 volution | 5.5 | 9.5 | 13.0 | 2.4 | 1.4 | 7.0 | 1.8 | — | — |
| at 2 volutions | 8.5 | 11.5 | 29.0 | 3.0 | 1.4 | 16.5 | 1.8 | — | — |
| at 2¾ volutions | 12.5 | 37.0 | 55.0 | 4.4 | 1.5 | 32.0 | 1.2 | — | — |

B = height of blade
M = height of middle portion
a = height of volution
N = length of narrowed base.
sh = height of shaft

Karpinsky, in 1899 (pp. 404–416) distinguished the following kinds of dentine in *Helicoprion bessonowi:*

(1) "Stark poröses schwammiges Vasodentin," corresponding to Röse's trabecular dentine and to Tomes' osteodentine, with an immense number of anastomosing canals. This dentine makes up the shaft and is penetrated by a longitudinal canal.

(2) "Faseriges Vasodentin," concentrically surrounding the former. This is a denser variety of dentine which contains another longitudinal canal, penetrating the middle portion of the teeth.

(3) The inner part of the spiral above the last mentioned canal is filled with dentine with "Haversian" canals; from the latter very fine dentinal tubes run towards the denticles of the blades.

(4) "Feinfaseriges Vasodentin" in those places where the bases of the teeth are in contact with each other. This dentine is clearly visible only in longitudinal sections.

(5) "Röhrenvasodentin" or "Parallelröhrenvasodentin" which forms the outer layer of dentine in those places where the spiral is covered by enamel. This "Röhrenvasodentin" is penetrated by a great number of, sometimes dichotomous, dentinal tubes, arranged vertically to the surface of the teeth.

The outermost layer of the teeth is referred to by Karpinsky as "emailartige Schicht" or "Placoinschmelz" (1899, pp. 417–419). Here Karpinsky acted under the influence of earlier observers (Hertwig and others) who regarded the enamel of selachian teeth as structurally different from the enamel of other vertebrates. In view of Weidenreich's recent discovery (1926) that this much discussed outer layer of selachian teeth actually is identical with the enamel of other vertebrates, it is probably justifiable to regard Karpinsky's "emailartige Schicht" as true enamel. This enamel layer can also be seen in the present specimen of *Helicoprion davisii* (see dark layer on right side of specimen pl. 22, fig. 3). Its thickness in this specimen increases from about 0.1 mm. in the lower middle part to about 0.2 mm. in the upper part of the cross-section of the spiral.

In all probability, Karpinsky's five varieties of dentine must be regarded as true osteodentine.[1] Karpinsky himself (1899, p. 416) regarded the "Röhrenvasodentin" as true dentine, but it is more probably a variety of osteodentine. The dentinal tubes as they pass inwards become gathered together (see Karpinsky 1899, p. 417) into larger canals which originate from the larger "Haversian," canals of the inner layer of osteodentine. The general structure is somewhat similar to that of a pike's tooth which also possesses an outer layer of fine-tubed osteodentine (see Tomes, 1914, pp. 98, 99).

The inner osteodentine, Karpinsky's "schwammiges Dentin" and the "dentine with Haversian canals," forms a meshwork of irregular channels which is penetrated by two longitudinal canals, one of them in the upper part of the shaft which may be called the "proximal canal," the other near the base of the middle portion of the "teeth" which may be called the "distal canal." Both canals were described in detail by Karpinsky in 1915. The distal canal of *Helicoprion davisii* is well shown in the cross-section plate 22, figure 3. Its cross-section is circular and its diameter 1.1 mm. A reconstruction of this canal, "gros canal longeant," in *Helicoprion bessonowi* was published by Karpsinky (1915, p. 132). The proximal canal is not clearly marked in the same cross-section, but is well seen in the third specimen to be described below.

From the upper part of the porous osteodentine (Karpinsky's "dentine with Haversian canals") issue a great number of medullary canals, longitudinal to the axis of the teeth. Some of these canals penetrate the entire length of the teeth in the man-

[1] Without more detailed histological studies it will be difficult to describe the dentine of *Helicoprion* in terms of Weidenreich's recent classification (1925). It is possible that Karpinsky's varieties (1), (2) and (4) correspond to Weidenreich's "feinfibrilläres" or "circumpulpäres Dentin," whereas Karpinsky's "Röhrenvasodentin" may be identical with Weidenreich's "grobfaseriges" or "Manteldentin." As has been pointed out by Nielsen (1932, p. 28), it is difficult to homologize Weidenreich's classification of dentine with those previously in vogue. Weidenreich's classification is based on observations of ontogenetic development, whereas previous classifications are merely descriptive, although still indispensable, where, as in the present case, ontogenetic observations are impossible.

ner illustrated by Karpinsky 1899, p. 404, and pl. 3, fig. 8). In *Helicoprion davisii* the medullary canals can be seen in the upper part of the cross-section (pl. 22, fig. 3) and in the coronal view of the teeth (pl. 22, fig. 4).

*Third specimen* (nos. 19221 a and b, Department of Geology, University of Western Australia, Crawley) (pl. 23): Two specimens which are parts of the external moulds of one and the same spiral. The complete spiral consisted of almost exactly three volutions of which over two are well shown in the larger of the moulds (pl. 23, fig. 3), whereas most of the last volution is broken off or only shown in part. The opposite mould (pl. 23, fig. 1) represents only a little more than one and a half volutions of the specimen. The number of teeth in one volution is 38. Measurements of the teeth are given in table. 1.

The state of preservation of these moulds is inferior to that of the holotype, and the presence of serrated edges of the blades cannot be ascertained. As will be seen in table 1 the teeth of the middle part (second volution) have relatively shorter blades and longer middle portions than those of the first volution whose proportions are more similar to those of the holotype. In this connection, it will be noted that the relative length of the blades also changes considerably in *Helicoprion bessonowi*. Unfortunately, in the present specimen the outermost third volution is so imperfectly preserved that no direct comparison can be made with the holotype, which apparently represents part of the third volution of a specimen. Owing to the unsatisfactory state of preservation of the specimen, measurements of the apical angle of the teeth are unreliable, and no definite figures can be given.

In a few places traces of the osteodentine of the shaft are still preserved, and portions of the proximal canal can be seen. This structure was first observed by Karpinsky in 1899 (p. 405) and later described in more detail by the same author in 1915 (p. 132) as "canal longitudinal inferieur." In the present specimen of *Helicoprion davisii* it appears on the smaller mould along the second half of the first volution as a thin cylindrical rod of about 0.4 mm. diameter (pl. 23, fig. 2). A small piece of it is also seen in the larger mould in the beginning of the second volution, where it is 0.6 mm thick (pl. 23, fig. 4). The cross-section of the canal is more or less circular; its surface is slightly irregular and the places where small side canals enter are clearly visible.

*Discussion.*—The second specimen (no. G 8523) described above apparently agrees more closely with the holotype of *Helicoprion davisii* than does the third specimen (no. 19221). The relative length of the blades is shorter in this specimen, as compared with the holotype, but it also varies in specimens of *Helicoprion bessonowi*. Another difference can be noted in the angle between the longitudinal axis of the middle portions and of the blades of teeth and their narrowed bases as it appears from the following table:

TABLE 2.—ANGLE BETWEEN LONGITUDINAL AXIS AND BASE OF THE TEETH

| | |
|---|---|
| *Helicoprion davisii* | |
| (1) Holotype (no. 9080): | |
| largest tooth | 122° |
| smallest tooth | 119° |
| (2) Second specimen (no. G. 8523) | |
| middle tooth | 117° |
| (3) Third specimen (no. 1922) | |
| at ½ volution | 127° |
| at 1 volution | 128° |
| at 1¾ volutions | 130° |
| at 2 volutions | 126° |
| *Helicoprion bessonowi* | |
| Karpinsky's specimen 1899, pl. 1 | |
| at ½ volution | 121° |
| at a little over 1 volution | 123° |
| at 2 volutions | 124° |
| at 2¾ volutions | 128° |
| Karpinsky's specimen 1899, pl. 2 | |
| at ½ volution | 115° |
| at 1 volution | 119° |
| at 2 volutions | 121° |
| at 2½ volutions | 110° |

It will be seen that this angle in the third specimen of *H. davisii* agrees more closely with conditions observed in the holotype of *H. bessonowi* than with those in the holotype of *H. davisii*. In this respect, holotype and second specimen of *H. davisii* are in perfect harmony. On the other hand, in *H. bessonowi*, too, the angle of deflection is apparently variable as illustrated by the figures in table 2 for the second specimen figured by

Karpinsky. The proportions of the teeth of the third specimen of *H. davisii* (compare table 1) agree better with those of the holotype of that species than with those of the holotype of *H. bessonowi*. The height of the volutions increases more rapidly in *H. bessonowi* than in the third specimen of *H. davisii* and in this respect there is greater similarity between the holotypes of the two species.

There are also differences in the number of teeth per volution. In the holotype of *H. davisii* this number is probably not greater than 35, in the third specimen described above it is 38, and in *H. bessonowi* it is 43.

It appears, therefore, that the third specimen described above is in many respects intermediate between the holotypes of *H. bessonowi* and *H. davisii*. Nevertheless, at the present moment the creation of a new species for that specimen is thought to be unwarranted. It is here included in *H. davisii* and thought to indicate the close relationship between this species and *H. bessonowi*. Karpinsky himself has emphasized (1912, p. 83) that there is a considerable variability in *H. bessonowi* and a similar variability must be expected in *H. davisii*. If ever a complete spiral of *Helicoprion* should be found in Western Australia, the two species may prove to be identical. On the other hand, if future finds should reveal the presence of two species of *Helicoprion* in Western Australia, this would not be altogether surprising in view of the fact that holotype and second specimen are possibly derived from a lower stratigraphic horizon than the third specimen. This possibility has been discussed in a previous section.

The Uralian *Helicoprion ivanovi* (Karpinsky 1922 b) differs in several respects from *H. bessonowi* as well as from all the specimens here referred to *H. davisii*. The teeth are relatively narrower; the narrowing of the bases is much more gradual and the narrowed bases are relatively longer. Also the bases are deflected at a greater angle (up to 140°) and the width of the shaft is relatively less, so that the cross-section of the spiral is more slender than in both *H. bessonowi* and *H. davisii*. It can, therefore, be stated that *H. davisii* is more closely related to *H. bessonowi* than to *H. ivanovi*.

In 1912 (p. 92) Karpinsky stated that *H. davisii* was more closely related to *H. ferrieri* (Hay) than to any other species of the genus. However, as Wheeler has already pointed out, the shaft of the latter species is much higher. Also, the apical angle of the teeth is smaller than in *H. davisii*. In respect to the height of the shaft *H. ferrieri* agrees better with the Japanese specimen described by Yabe (1903) as *H. bessonowi*. In many respects this Japanese specimen is closely similar to the third specimen of *H. davisii* (no. 19221), especially in the proportions of the teeth, though on account of the height of its shaft it may be more closely related to *H. ferrieri* than to either *H. bessonowi* or *H. davisii*. However, these three species apparently form one group of closely allied specimens.

*Acknowledgments.*—I wish to thank Mr. W. A. Rainbow, of the Australian Museum, Sydney; Mr. K. W. Burrow, of the Fisher Library, Sydney; Mr. R. J. Smith, of the Dental Hospital, Perth; and Dr. T. Kobayashi, of the Imperial University,Tokyo, for their valuable assistance in securing copies and reproductions of rare books and papers which had to be consulted during the preparation of this manuscript.

## REFERENCES

BRANSON, C. C., *1935*, A Labyrinthodont from the Lower Gondwana of India and a new Edestid from the Permian of the Salt Range: *Connecticut Acad. Arts and Sci., mem.*, vol. 9, 9 pp. 19–26, 2 pls.

CLARKE, E. DE C., *1938*, Correlation of the Carboniferous and Permian formations of Australia. II. Western Australia: *Australian and*

## EXPLANATION OF PLATE 23

FIGS. *1–4*—*Helicoprion davisii* (Woodward). External moulds of one specimen (nos. 19221 a and b Department of Geology University of Western Australia), 200 yards north of Wandagee-Minilya road, west side of syncline, north of Wandagee Hill, lower part of *Fenestella* beds of Wandagee stage; *2* and *4* are enlarged portions of *1*, (no. 19220 b) and *2*, (no. 19220 a) to show the longitudinal "proximal" canal in the shaft, ×3. (p. 145)

Teichert, Australian Helicoprion

UNIV. OF

*New Zealand Assoc. Adv. Sci. Rept.* (1937), vol. 23, pp. 426–430.

DAVID, T. W. E., *1928*, On the occurrence of the genus *Helicoprion*, possibly *Toxoprion*, in the so-called Permo-Carboniferous rocks of Western Australia: *3rd Pan-Pacif. Cong. Tokyo Proc.* (1926), vol. 2, pp. 1845–1849.

DAVID, T. W. E., and SUSSMILCH, C. A., *1931*, Upper Palaeozoic glaciation of Australia: *Geol. Soc. America Bull.*, vol. 42, pp. 481–522.

——, *1936*, The Carboniferous and Permian periods in Australia. *Int. Geol. Cong. Rept. XVI* (1933), vol. 1, pp. 629–644.

EASTMAN, C. R., *1902*, On *Campyloprion*, a new form of *Edestus*-like dentition: *Geol. Mag.*, n.s., dec. 4, vol. 9, pp. 148–152.

FUCHS, T., *1900*, Neber die Natur der Edestiden, mit besonderer Rücksicht auf die Gattung *Helicoprion: Akad. Wiss. Wien, Math.-naturwiss. Kl., Sitz.-Ber.*, vol. 109, A Ct. I, pp. 5–9, 1 pl.

HAY, O. P., *1907*, A new genus and species of fossil shark related to *Edestus* Leidy: *Science*, n. s., vol. 26, pp. 22–24.

——, *1909*, On the nature of *Edestus* and allied genera: *U. S. Nat. Mus. Proc.*, vol. 37, pp. 43–61, pls. 12–15.

——, *1912*, On an important species of *Edestus* with descriptions of a new species, *Edestus mirus: U. S. Nat. Mus. Proc.*, vol. 42, pp. 31–38, 2 pls.

——, *1929*, Second Bibliography and catalogue of the fossil vertebrates of North America: *Carnegie Inst. Washington, Pub.*, no. 390, vol. 1.

HOFFET, J. H., *1933*, Etudes géologiques sur le contre de l'Indochine entre Tourane et le Mikong: *Service géol. Indochine, Bull.*, no. 20. fasc. 2, 154 pp., 4 pls.

KARPINSKY, A., *1899*, Ueber die Reste von Edestiden und die neue Gattung *Helicoprion: Russ. k. min. Gesell. Verh.*, ser. 2, vol. 36, pp. 361–476, 4 pls.

——, *1911*, Note sur *Helicoprion* et les autres Edestides: *Acad. Sci. St. Pétersbourg Bull.*, ser. 6, vol. 5, pp. 1105–1122.

——, *1912*, On *Helicoprion* and other Edestidae: *Russ. K. min. Gesell. Verh.*, ser. 2, vol. 49, pp. 69–94.

——, *1915*, Notice sur la nature de l'organe héliçoidal du *Helicoprion: Soc. Oural. Amis Sci. Nat. Bull.*, vol. 35, pp. 117–145, 1 pl.

——, *1916*, On a new species of *Helicoprion* (*Helicoprion clerci* n. sp.): *Acad. Sci. Pétrograd Bull.*, ser. 6, vol. 10, pp. 701–708.

——, *1922*, a, Notice sur les ségments dentaires des edestides et leur orientation: *Acad. Sci. Russie Bull.*, ser. 6, vol. 16, pp. 379–388.

——, *1922*, b, *Helicoprion ivanovi* n. sp.: *Acad. Sci. Russie Bull.*, ser. 6, vol. 16, pp. 369–378.

——, *1925*, Sur une nouvelle trouvaille de restes de *Parahelicoprion* et sur les relations de ce genre avec *Campodus: Soc. géol. Belgique, 50me anniv. Livre jubil. 1874–1924*, vol. 1, fasc. 1, pp. 127–137.

KLAATSCH, H., *1901*, Zur Deutung von *Helicoprion* Karp: *Centralbl. f. Mineralogie Geol., Pal.*, pp. 429–436.

KOKEN, E., *1901*, *Helicoprion* im Productus-Kalk der Salt Range: *Centralbl. f. Mineralogie* etc., pp. 225–227.

——, *1907*, Indisches Perm und permische Eiszeit: *Neues Jahrb. Min. etc. Festband*, pp. 446–546.

MILLER, A. K., and CLINE, L. M., *1934*, The Cephalopods of the Phosphoria Formation of Northwestern United States: *Jour. Paleontology*, vol. 8, pp. 281–302, 1 pl.

NIELSEN, E., *1932*, Permo-Carboniferous fishes from East Greenland: *Meddelelser om Grønland*, vol. 86, no. 3, 63 pp. 16 pls.

RAGGART, H. G., *1936*, Geology of North-West Basin, Western Australia, with particular reference to the stratigraphy of the Permo-Carboniferous: *Royal Soc. New South Wales Jour. and Proc.*, vol. 70, pp. 100–174.

RAGGATT, H. G., and FLETCHER, H. O., *1937*, A contribution to the Permian-Upper Carboniferous problem and an analysis of the fauna of the Upper Palaeozoic (Permian) of North-West Basin, Western Australia: *Australian Mus. Rec.*, vol. 20, pp. 150–184.

ROMER, A. S., *1933*, Vertebrate Paleontology, 491 pp., Chicago.

SCHUCHERT, C., *1928*, Review of the Late Paleozoic formations and faunas, with special reference to the ice-age of Middle Permian time: *Geol. Soc. America Bull.*, vol. 39, pp. 769–886.

TEICHERT, C., *1939a*, Recent research work in the Permian of Western Australia: *Australian Jour. Sci.*, vol. 2, pp. 5–7.

——, *1939b*, Review of Western Australian Upper Palaeozoic: Correlation, palaeogeography, tectonics: *Australian and New Zealand Assoc. Adv. Sci. Rept. (1939)*, vol. 24, 1939, pp. 92–93.

TOMES, C. S., *1914*, A Manual of Dental Anatomy, 7th ed., 616 pp. London. (8th ed. 1923. Not seen.)

WATERFORD, L. M., Geological reconnaissance of part of the Northwest Basin: (Undated map printed by Freney Oil Company Ltd., Perth, Western Australia).

WEIDENREICH, F., *1925*, Ueber den Bau und die Entwicklung des Zahnbeins in der Reihe der Wirbeltiere: *Archives Russ. anat., hist., embryol.*, vol. 76.

——, *1926*, Ueber den Schmelz der Wirbeltiere und seine Beziehungen zum Zahnbein: *Zeitschr. Anat. u. Entwicklungsgesch.*, vol. 79.

WHEELER, H. E., *1939*, *Helicoprion* in the Anthracolithic (late Paleozoic) of Nevada and California and its stratigraphic significance: *Jour. Paleontology*, vol. 13, pp. 103–114.

WHITE, E. G., *1936*, A classification and phylogeny of Elasmobranch fishes: *Am. Mus. Novitates*, no. 837, pp. 1–16.

WOODWARD, A. S., *1921*, Observations on some extinct Elasmobranch fishes: *Linnean Soc. London. Proc.*, vol. 133, pp. 29–39.

WOODWARD, H., *1886*, On a remarkable ichthyodorulite from the Carboniferous series, Gascoyne, Western Australia: *Geol. Mag.*, n. s., dec. III, vol. 3, pp. 1–7, 1 pl.

YABE, H., *1903*, On a Fusulinid-limestone with *Helicoprion* in Japan: *Geol. Soc. Tokyo Jour.* vol. 10, no. 113, pp. 1–13, 2 pls.

MANUSCRIPT RECEIVED BY EDITOR, NOV. 22, 1939.

JOURNAL OF PALEONTOLOGY, VOL. 14, NO. 2, PP. 150–153, PL. 24, MARCH, 1940

# THE GASTROPOD GENUS EUPHEMITES IN THE PENNSYLVANIAN OF TEXAS

RALPH H. KING
University of Kansas, Laurence, Kansas

ABSTRACT—Four species of *Euphemites* are recorded from Pennsylvanian rocks of Texas. Their range and distribution are discussed. The species *Euphemites carbonarius* (Cox), so widely cited in the literature, appears to be unrecognizable. Therefore the proposal is made that the name be abandoned.

SPECIMENS referable to the gastropod genus *Euphemites* Warthin (1930) are abundant in the Pennsylvanian strata of Texas. They weather out readily from highly fossiliferous shales of the Mineral Wells, Graford, Caddo Creek, and Graham formations, and a few specimens are to be found in nearly all formations from the Millsap Lake (Sellards, 1933) upward through the Pueblo.

The collections of the Bureau of Economic Geology, of the University of Texas, contain a large number of these specimens. Their diversity of form and ornamentation invites an attempt to differentiate several species. Accordingly, a thorough review of the literature has been undertaken and the following conclusions have been reached:

(1) No American species is identical with *Euphemites urii* (Fleming, 1842). This is contrary to Keyes' contention (Keyes, 1894) that *E. urii* occurs in this country. (2) *Euphemites carbonarius* (Cox) is not a valid species. (3) *Euphemites vittatus* (McChesney) and *E. blaneyanus* (McChesney) are both valid, though both names are by most authors included in the synonymy of *E. carbonarius* (Cox).

The following chart indicates the range of species of *Euphemites* in Texas.

The genus *Euphemites* comprises subglobular, non-carinate, lirate Bellerophontidae called *Euphemus* by McCoy (1844), a preoccupied generic name. Species of this genus flare only slightly at the aperture, and the whorl section is reniform, varying to subquadrate or sublunar. Of the known American forms none are umbilicate. In all species except *E. callosus* (Weller) the inner lip is formed by the outer surface of the preceding volution without callosity of any sort. The nearest approach to carination is exhibited by *E. nodocarinatus* (Hall), which is marked by a nodose double carina on the non-lirate portion of the shell. *E. inspeciosus* (White) also has a distinct but non-nodose double carina on this portion of the shell. *E. subpapillosus* (White), a Permian form, is readily distinguished by the character of its lirations, which instead of being continuous elevations break up into rows of small nodes that cover the portion of the shell that is smooth in other species of the genus.

## SYSTEMATIC DESCRIPTIONS

### Genus EUPHEMITES Warthin

### EUPHEMITES VITTATUS (McChesney)

Plate 24, figures 4, 5

*Bellerophon urii*, NORWOOD and PRATTEN, *1855*, (non Fleming, *1828*), Acad. Nat. Sci., Phila-

| Species of *Euphemites* | Millsap Lake | Mineral Wells | Palo Pinto | Graford | Brad | Caddo Creek | Graham | Thrifty | Harpersville | Pueblo |
|---|---|---|---|---|---|---|---|---|---|---|
| *E. vittatus* (McChesney) | — | — | — | x | x | x | x | x | x | x |
| *E. blaneyanus* (McChesney) | x | x | — | x | x | — | — | — | — | — |
| *E. inspeciosus* (White) | — | x | — | x | — | — | — | — | — | — |
| *E. nodocarinatus* (Hall) | x | — | — | — | — | — | — | — | — | — |

delphia Jour., ser. 2, vol. 3, p. 75, pl. 9, figs. 6a–c.

*Bellerophon vittatus* McCHESNEY, *1860*, Descriptions of new Paleozoic fossils, p. 59.

*Bellerophon carbonarius*, MEEK, *1872*, U. S. Geol. Survey of Nebraska, p. 224, pl. 4, fig. 16, pl. 11, figs. 11a–c.—WHITE, *1884*, Indiana Geol. Survey, 13th Rept., p. 158.

*Euphemus carbonarius*, GIRTY, *1915*, U. S. Geol. Survey Bull. 544, p. 174.

Norwood and Pratten did not describe the specimens that they referred to *Bellerophon urii* Fleming, but they cited three localities and figured, incorrectly, a single specimen obtained from Cox and supposedly deposited in the Illinois State Collection. Cox (1857) pointed out differences between their specimen and figures. He described the species and to it gave the name *B. carbonarius*. He based his description on the specimen loaned by him to Norwood and Pratten. He did not mention a type locality nor reillustrate the form, and the type is now lost. Only the Grayville locality of Norwood and Pratten can logically be considered as the type locality[1] and two species of this genus were described by McChesney from that place. It is doubtful whether either of them is the form that Cox described, for both are nodose near the axis and somewhat subtriangular in outline and the sides of the mouth are not extended to form ears. In all these respects they differ from the form described by Cox. As the type of Cox's species was never properly illustrated and is now lost, and as no type locality was named, his species must be regarded as invalid and unrecognizable. McChesney's name *vittatus* may be accepted for the form noted by Norwood and Pratten. McChesney described the form in detail and listed Grayville among his localities. The name was proposed as a substitute for the preoccupied *urii* and there can be little doubt that they are the same form, though neither was figured.

*E. vittatus* (McChesney) has about 18 to 22 lirations, but the exact number is difficult to determine as the axial lirae develop from irregular rows of nodes that extend beyond the central lirae. Irregular spacing and unequal strength of the lirae is noticeable, particularly on the slit band, which on many specimens is limited by strong lirae that continue to the aperture across the otherwise smooth portion of the shell.

The whorl section is high, expanding most rapidly at the sides and at the slit band, and thus acquires at maturity in some specimens a subtriangular outline, although this shape is not pronounced except in a few individuals. On individuals whose whorls expand laterally at the sides rather than in the direction of curvature of the whorl section, the columella is completely closed but depressed. If the whorl section expands uniformly it retains its semicircular cross section, and the axis is extended. The whorl section thus is highly variable, showing complete intergradation between the semicircular and subtriangular forms.

*Types.*—Hypotypes, Bureau of Economic Geology, coll. no. P 776, from the Graham formation a mile south of Gunsight, Stephens County, and about half a mile north of the Stephens-Eastland County line, and coll. no. 7124, from the Graford formation, exposed on the west side of Martin's Lake about 2 miles south of Bridgeport, Wise County.

### EUPHEMITES BLANEYANUS (McChesney)
Plate 24, figures 1–3

*Bellerophon blaneyanus* McCHESNEY, *1860*, Descriptions of new Paleozoic fossils, p. 60.—McCHESNEY, *1865*, Illustration of New Species of Fossils, pl. 2, figs. 5a–c.—McCHESNEY, *1868*, Chicago Acad. Sci. Trans., vol. 1, p. 45, pl. 2, figs. 5a–c.

This is a small species, the maximum diameter observed being about 12 mm. Its size is remarkably uniform, most of the Texas specimens having a diameter of 9 mm or more, which is about the size of the specimen figured by McChesney. It is markedly depressed axially but the umbilicus is filled by a smooth callus.

The lirations number rather uniformly 16 or 17 though a few specimens show as few as 14 or as many as 19. A few short lirations run diagonally forward from the axis toward the slit band at the point where the revolving lirae end, but they extend only about 2 mm. On most specimens these lirae are partly replaced by small nodes. The whorl section is high and somewhat subtriangular. All these features indicate the

[1] Weller, J. Marvin, personal communication, June 1, 1933.

relationship of *E. vittatus* (McChesney) to this form. Intermediate forms occur near the middle of the Mineral Wells formation.

*E. blaneyanus* (McChesney) can be distinguished from all other American Euphemitids by the callus-filled depression at the axis and by the short diagonal lirae. Its small size seems also to be distinctive.

*Types.*—Hypotypes, Bureau of Economic Geology, coll. no. 7956, from the Mineral Wells formation exposed one-fourth mile northwest of Union Hill school, which is 6 miles north-northwest of Mineral Wells, Palo Pinto County, and a topotype, coll. no. 12272 from Grayville, Ill., presented by Dr. J. Marvin Weller.

### EUPHEMITES INSPECIOSUS (White)
Plate 24, figure 6.

*Bellerophon inspeciosus* WHITE, *1881*, U. S. Geol. Survey W. of 100th Mer., Rept., vol. 3, Supp. App., p. xxx, pl. 4, figs. 1a–d.

The collection contains a few specimens of this striking shell. Instead of being coiled in a regular, even curve, this species is sharply geniculate at two points a third of a volution apart. At the first geniculation four alternate lirae over the center of the shell stop abruptly, and at the second the rest of the lirae disappear and the carina appears. None of the lirae break up into nodes. On some specimens there is a groove on each side of the carina.

The whorl section is low and broad, expanding laterally very rapidly. A section perpendicular to the axis is subtriangular, owing to the geniculations.

*Types.*—Hypotypes, Bureau of Economic Geology, coll. no. P 645, from the Graford formation exposed along the Brownwood-Bangs road, 2.5 miles west of Brownwood, Brown County.

### EUPHEMITES NODOCARINATUS (Hall)
Plate 24, figure 7

*Bellerophon nodocarinatus*, HALL, *1858*, Geology Iowa, vol. 1, pt. 2, p. 723, pl. 29, figs. 15a–c.

This species differs from others in the extreme thickness of its shell, the presence of nodes on the carina, and in the pronounced extension of the lateral margins at the aperture. A specimen having a diameter of 20 mm has a thickness of 8 mm measured radially at the slit band and measures 5 mm across the aperture. The total height of the whorl section, therefore, is nearly twice the diameter of the entire shell at a point half a volution farther back. This extremely rapid expansion of the shell throws the axis far from the geometric center.

Beyond the point where the lirations terminate, the carina becomes noticeable and is ornamented with two rows of large, circular, rounded nodes limiting the slit band. This portion of the shell is broken off most specimens.

Near the aperture the lateral margins thicken and flare outward, and this expansion together with the elevation of the carina gives the exterior outline of the aperture a somewhat trifid appearance, but the interior outline is a smooth curve.

The shell is strongly geniculate at two points, as is *E. inspeciosus* (White). This feature is not mentioned in Hall's brief description but the second geniculation is shown in his figure 15b. The first genicula-

---

### EXPLANATION OF PLATE 24

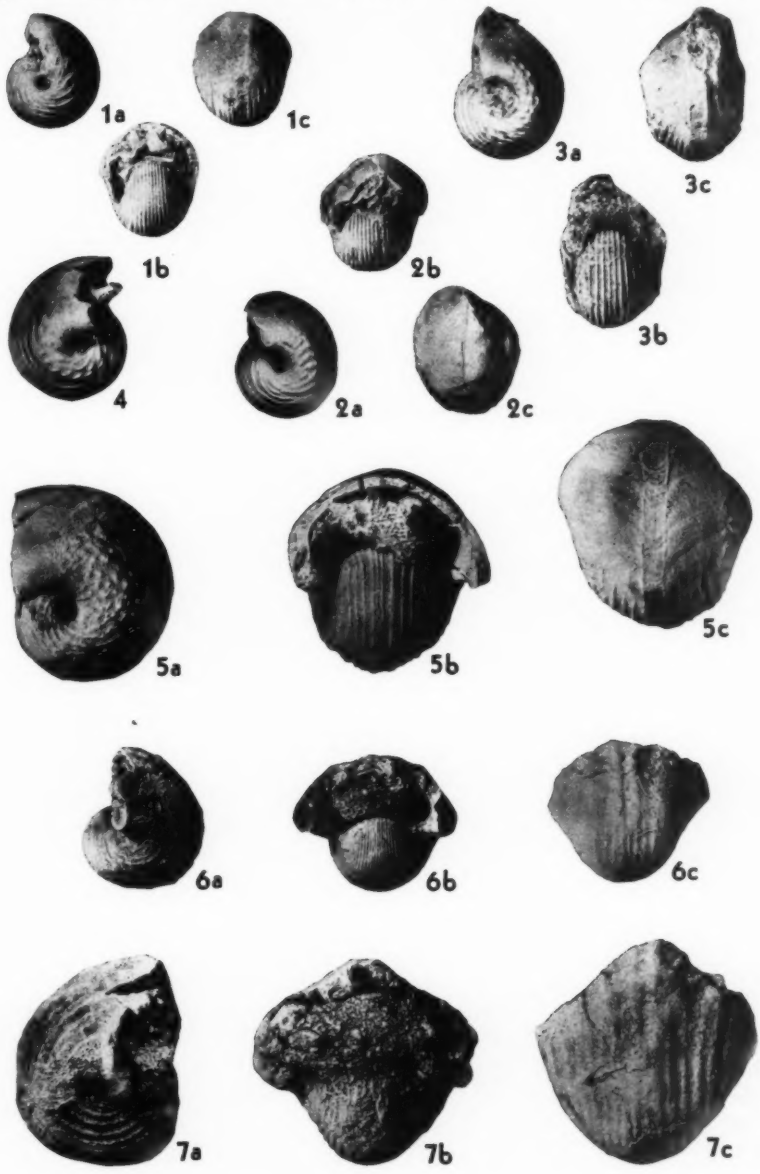
All specimens are broken about the aperture.

FIGS. *1–3*—*Euphemites blaneyanus* (McChesney), ×1.5. *1, 2*, Two specimens from the Mineral Wells formation showing the diagonal lirae near the axis; *3*, Topotype from Grayville, Illinois, somewhat distorted and not entirely freed from the matrix. The prominence of the slit band is due to crushing. (p. 151)

*4–5*—*Euphemites vittatus* (McChesney), ×1.5. *4*, Specimen from Graham formation a mile south of Gunsight. Method of addition of lirae is well shown; *5*, Rather large specimen from Graford formation south of Bridgeport. (p. 150)

*6*—*Euphemites inspeciosus* (White), ×1.5. Small specimen from the Graford formation 2.5 miles west of Brownwood. The area bordering the carina is somewhat depressed on this individual. (p. 152)

*7*—*Euphemites nodocarinatus* (Hall), ×1.5. Specimen from Millsap Lake formation southwest of Millsap. Only a few faint nodes are visible, the strongly nodose portion of the shell having been broken off. (p. 152)




King, Pennsylvanian Gastropod

UNIV. OF MICH.

tion is concealed by the outer whorl, but is plainly visible on the broken specimens ordinarily found.

Hall gives the number of lirations as 14 or 16, but this number is variable with the stage of growth. The lirae increase by axial addition and on some specimens fine lirae are intercalated. These may continue for a quarter of a volution and then die out or may attain the usual size and continue about the shell.

This species is not likely to be confused with any other so far known unless it be *E. inspeciosus* (White), which is also carinate near the aperture, and geniculate. However, the carina of *E. inspeciosus* (White) is smooth rather than nodose. Furthermore, the second geniculation coincides with the point of discontinuation of the lirae and rise of the carina, whereas on *E. nodocarinatus* (Hall) the second geniculation occurs about a third of a volution farther back. The manner in which the lateral margins round into the axis is similar in *E. nodocarinatus* (Hall) and *E. vittatus* (McChesney) but in no other respect are they sufficiently similar to cause confusion.

*Type.*—Hypotype, Bureau of Economic Geology, coll. no. 11384, from the Millsap Lake formation 5.5 miles southwest of Millsap and 0.15 miles south of Goen Cemetery on the Gordon road, Palo Pinto County.

NOTE: The preparation of this paper was aided by a grant from the Penrose Bequest of the Geological Society of America.

## REFERENCES

COX, E. T., *1857*, Paleontological report of Coal Measures Mollusca: *Kentucky Geol. Survey*, vol. 3, p. 562.

FLEMING, JOHN, *1828*, A History of British Mammals, p. 338. Edinburgh (reprinted, *1842*).

KEYES, CHARLES ROLLIN, *1894*, Paleontology of Missouri, Part 2: *Missouri Geol. Survey*, vol. 5, p. 149.

MCCOY, F., in GRIFFITH, R., *1844*, Synopsis of Characteristic Carboniferous Limestone Fossils of Ireland, p. 25, Dublin.

SELLARDS, E. H., *1933*, The Pre-Paleozoic and Paleozoic Systems in Texas: *Texas Univ. Bull.*, 3232, pt. 1, p. 107.

WARTHIN, ALDRED S., Jr., *1930*, Micropaleontology of the Wetumka, Wewoka, and Holdenville Formations: *Oklahoma Geol. Survey Bull.*, 53, p. 44.

MANUSCRIPT RECEIVED BY THE EDITOR, MAY 19, 1939.

JOURNAL OF PALEONTOLOGY, VOL. 14, NO. 2, PP. 154–163, MARCH, 1940

# PALEONTOLOGICAL NOTES

## CHECK LIST OF MISSISSIPPIAN OSTRACODA OF NORTH AMERICA

I. G. SOHN
Columbia University, New York

THE DRILLING activities in the Illinois oil basin during the past few years stimulated the publication of several papers on Upper Mississippian Ostracoda. This is due to the fact that fossils of this group are helpful in subsurface correlation of the sediments associated with the petroliferous deposits.

To facilitate the use of fossils of this group for such correlation, this check list of Mississippian Ostracoda was drawn up. The list shows the formations from which given species have been described. The valid name of each species where synonomy occurs is listed, except in the two cases discussed subsequently. The formation from which a synonym has been described is listed after the valid name only.[1]

*Pontocypris ? acuminata* Ulrich, 1891 (1891, p. 21, pl. 17, fig. 8 a, c), is preoccupied by *P. acuminata* (Alth) (1850) in Jones and Hinde, 1890 (A Supplementary Monograph of the Cretaceous Entomostraca of England and Ireland, Paleontographical Soc., p. 3), where they refer *Cytherina acuminata* to *P. acuminata* (Alth), 1850.

The writer was advised by Dr. Ulrich's office that it may be best not to rename *Pontocypris ? acuminata* because the species was originally questionably placed in the genus *Pontocypris* and future study may remove that species from this genus. If the species were shifted to a new genus, the specific name would be valid, and any new name would become a synonym. *P. ? acuminata* consequently appears in the list.

*Bairdia contracta* Morey, 1935 (1935a, p. 480, pl. 54, fig. 11, 12), is preoccupied by *B. contracta* Jones, 1856 (A Monograph of the Tertiary Entomostraca of England. Paleont. Soc. p. 53, pl. 5, fig. 1a–c).

[1] One method of correlation by statistical means is described by Dr. C. Croneis in "A New Type of Paleontological Table", *Am. Jour. Sci.*, vol. XX, pp. 339–343 (1930).

The writer has as yet not received a suggestion for a new name from Dr. Morey, consequently the invalid name, *B. contracta* Morey, 1935, appears on the list.

*Bairdia depressa* Geis, 1932 (1932, pl. 178, pl. 25, fig. 12a–b), is preoccupied by *B. depressa* Kofka, 1887 ("Kritische Verzeichniss die Ostracoden der böhmischen Kreideformation" in "Die Crustaceen der böhmischen Kreideformation" by A. Fritsch and J. Kofka).

At Dr. Geis's suggestion the name *Bairdia distressa* Geis, 1940, is here designated as a new name for *B. depressa* Geis, 1932.

The genus *Reversabella* Coryell and Johnson, 1939, is congeneric with *Persansabella* Coryell and Sohn, 1938, consequently the species in *Reversabella* are here shifted to *Persansabella*. *Sansabella johnsoni* Croneis and Thurman, 1939, and *S. harrisi* Croneis and Funkhouser, 1939, are shifted to the genus *Persansabella*.

The genus *Carboprimitia* Croneis and Funkhouser, 1939, is not congeneric with *Geffenina* Coryell and Sohn, 1938, nor with *Geffenites* Coryell and Sohn, 1938, but is probably congeneric with *Sansabella* Roundy, 1926. Due to the fact that Croneis and Funkhouser consider *Carboprimitia* different from *Sansabella* and that the writer has not examined any specimens of the former genus, *Carboprimitia* is here listed as a valid genus.

There are 364 species distributed in 82 genera listed from the Mississippian of North America. 314 of the species are listed from only one formation, 44 species from two formations and 6 species from three or more formations.

The writer wishes to thank Dr. H. N. Coryell for the use of his unpublished manuscript, "A Bibliographic Index of Ostracoda", and for his advice in solving many of the nomenclatorial problems.

TABLE 1.—CHECK LIST OF MISSISSIPPIAN OSTRACODA[2]

| | Kinderhookian | Osagian | Meramecan | Chesterian | |
|---|---|---|---|---|---|
| | | | | Lower | Upper |
| *Acratia deloi* Geis, 1932 | — | — | Salem | | |
| *A. disjunctus* Morey, 1935 | — | Amsden | | | |
| *A. similaris* Morey, 1936 | — | Chouteau | | | |
| *Aechmina longicornis* Ulrich and Bassler, 1932 | Ridgetop | | | | |
| *Allostraca fimbriata* Ulrich and Bassler, 1932 | Ridgetop | | | | |
| *Amphissites altonodosus* Geis, 1932 | — | — | Salem | | |
| *A. bicarinatus* Croneis and Thurman, 1939 | — | — | — | — | Kinkaid |
| *A. biforatus* Croneis and Thurman, 1939 | — | — | — | — | Kinkaid |
| *A. bradfieldi* Croneis and Funkhouser, 1939 | — | — | — | — | Clore |
| *A. centronotus* (Ulrich and Bassler), 1906 | — | — | Salem | — | Golconda |
| *A. chappellensis* Roundy, 1926 | — | — | — | Barnett | |
| *A. concavus* Croneis and Bristol, 1939 | — | — | — | — | Menard |
| *A. costellifera* Croneis and Bristol, 1939 | — | — | — | — | Menard |
| *A. decipiens* Croneis and Bristol, 1939 | — | — | — | — | Menard |
| *A. elongatus* Croneis and Bristol, 1939 | — | — | — | — | Menard |
| *A. fossilis* Croneis and Thurman, 1939 | — | — | — | — | Kinkaid |
| *A. genetivus* Morey, 1935 | Basal Miss. | Chouteau | | | |
| *A. grovei* Croneis and Gutke, 1939 | — | — | — | — | Renault |
| *A. insignis* Croneis and Thurman, 1939 | — | — | — | — | Kinkaid |
| *A. latinodus* Croneis and Bristol, 1939 | — | — | — | — | Menard |
| *A. lineatus* Croneis and Bristol, 1939 | — | — | — | — | Menard |
| *A. mimicus* Geis, 1932 | — | — | Salem | | |
| *A. monomastadis* Coryell and Sohn, 1938 | — | — | — | — | Reynolds |
| *A. nodosulcatus* Geis, 1932 | — | — | Salem | | |
| *A. ? obesus* Croneis and Gale, 1939 | — | — | — | — | Golconda |
| *A. oblongus* (Jones and Kirkby), 1867 | — | — | — | — | Glen Dean |
| *A. oblongus transversus* (Girty), 1910 | — | — | — | Fayetteville | |
| *A. peculiaris* Morey, 1935 | Basal Miss. | Chouteau | | | |
| *A. planoventralis* Geis, 1932 | — | — | Salem | | |
| *A. reflexus* (Girty), 1910 | — | — | — | Fayetteville | |
| *A. reticulatus* Geis, 1932 | — | — | Salem | | |
| *A. robertsi*, Morey, 1935 | — | Amsden | | | |
| *A. rotundus* Geis, 1932 | — | — | Salem | | |
| *A. rugosus* Girty, 1910 | — | — | — | Fayetteville | |
| *A. similaris* Morey, 1936 | — | Chouteau | | | |
| *A. similis* Croneis and Gale, 1939 | — | — | — | — | Golconda |
| *A. simplex* (Girty), 1910 | — | — | — | Fayetteville | |
| *A. subleneatus* Croneis and Thurman, 1939 | — | — | — | — | Kinkaid |
| *A. superus* Croneis and Gale, 1939 | — | — | — | — | Golconda |
| *A. tricollinus* (Jones and Kirkby), 1885 | — | — | — | — | Glen Dean |
| *A. trilobus* Croneis and Gale, 1939 | — | — | — | — | Golconda |
| *A. vanniae* Geis, 1932 | — | — | Salem | | |
| *A. warei* Morey, 1935 | — | Amsden | | | |
| *A. wilsoni* Croneis and Gutke, 1939 | — | — | — | — | Renault |
| *Aurigerites texanus* Roundy, 1926 | — | Boone | | | |
| *Bairdia attenuata* Girty, 1910 | — | — | Moorefield | Fayetteville | |
| *B. bedfordensis* Geis, 1932 | — | — | Salem | | |
| *B. cestriensis* Ulrich, 1891 | — | — | — | — | Glen Dean |
| *B. cestriensis granulosa* Girty, 1910 | — | — | — | Fayetteville | |
| *B. compacta* Geis, 1932 | — | — | Salem | | |
| *B. compressa* Geis, 1932 | — | — | Salem | | |
| *B. contracta* Morey, 1935 | — | Amsden | | | |
| *B. cooperi* Croneis and Gale, 1939 | — | — | — | — | Golconda |
| *B. delicata* Morey, 1935 | — | Amsden | | | |
| *B. distressa* Geis, 1940 | — | — | Salem | | |
| *B. fragosa* Morey, 1935 | Basal Miss. | Chouteau | | | |
| *B. galei* Croneis and Thurman, 1939 | — | — | — | — | Kinkaid |
| *B. gibbera* Morey, 1935 | Basal Miss. | Chouteau | | | |
| *B. golcondensis* Croneis and Gale, 1939 | — | — | — | — | Golconda, Renault, Menard |
| *B. granireticulata* Harlton, 1929 | — | — | — | Fayetteville | |
| *B. kinderhookensis* Morey, 1936 | — | Chouteau | | | |
| *B. lanulata* Harlton, 1929 | — | — | — | Fayetteville | |
| *B. mccoyi* Croneis and Gutke, 1939 | — | — | — | — | Renault |
| *B. magnacurta* Morey, 1935 | Basal Miss. | Chouteau | | | |
| *B. nasuta* Morey, 1935 | — | Amsden | | | |
| *B. ? osorioi* Croneis and Gale, 1939 | — | — | — | — | Golconda |
| *B. pecki* Morey, 1935 | Basal Miss. | Chouteau | | | |
| *B. permagna* Geis, 1932 | — | — | Salem | | |
| *B. renaultensis* Croneis and Gutke, 1939 | — | — | — | — | Renault |
| *B. salemensis* Geis, 1932 | — | — | Salem | | |
| *B. sinuosa* Morey, 1936 | — | Chouteau | | | |
| *B. subequalis* Geis, 1932 | — | — | Salem | | |
| *B. submucronata* (Jones and Kirkby), 1867 | — | — | — | Fayetteville | |
| *B. subparallela* Morey, 1935 | Basal Miss. | Chouteau | | | |
| *B. subroundata* Harlton, 1929 | — | — | — | Fayetteville | |
| *Bairdiolites brevirostris* Croneis and Thurman, 1939 | — | — | — | — | Kinkaid |
| *B. bulbosus* Croneis and Bristol, 1939 | — | — | — | — | Menard |

[2] The classification of formations used herein is for convenience only, and should not be construed as strictly defining age limits.

TABLE 1.—Continued

| | Kinderhookian | Osagian | Meramecan | Chesterian | |
|---|---|---|---|---|---|
| | | | | Lower | Upper |
| *B. crescentis* Croneis and Gale, 1939 | — | — | — | — | Golconda |
| *B. elongatus* Croneis and Funkhouser, 1939 | — | — | — | — | Menard |
| *B. emarginatus* Croneis and Bristol, 1939 | — | — | — | — | Clore |
| *B. ovatus* Croneis and Funkhouser, 1939 | — | — | — | — | Menard |
| *B. platipleurus* Croneis and Gale, 1939 | — | — | — | — | Clore |
| *Balantoides moryei* Croneis and Funkhouser, 1939 | — | — | — | — | Golconda |
| *B. quadrilobatus* Morey, 1935 | — | Amsden | | | Clore |
| *B. reticulatus* Croneis and Thurman, 1939 | — | — | — | — | Kinkaid |
| *Barychilina lineata* Ulrich and Bassler, 1932 | Ridgetop | | | | |
| *Beyrichia lithofactor* White and St. John, 1867 | — | — | St. Genevieve | | |
| *B. lithofactor velata* White and St. John, 1867 | — | — | St. Genevieve | | |
| *B. placida* Croneis and Gale, 1939 | — | — | — | — | Golconda |
| *Beyrichiella confluens* (Ulrich), 1891 | — | — | Warsaw | — | Chester |
| *Beyrichiopsis brynhildae* Coryell and Johnson, 1939 | — | — | — | — | Clore |
| *B. modesta* Ulrich and Bassler, 1932 | Ridgetop | | | | |
| *B. pulcra* Ulrich and Bassler, 1932 | Ridgetop | | | | |
| *B. thori* Coryell and Johnson, 1939 | — | — | — | — | Clore |
| *Bythocypris amsdenensis* Morey, 1935 | — | Amsden | | | |
| *B. clorensis* Croneis and Funkhouser, 1939 | — | — | — | — | Clore |
| *B. fayettevillensis* Harlton, 1929 | — | — | — | Fayetteville | |
| *B. incertus* Morey, 1935 | Basal Miss. | Chouteau | | | |
| *B. lydea* Geis, 1932 | — | — | Salem | | |
| *B. norrisensis* Geis, 1932 | — | — | Salem | | |
| *B. ulli* Coryell and Johnson, 1939 | — | — | — | — | Clore |
| *Carboprimitia depressa* Croneis and Funkhouser, 1939 | — | — | — | — | Clore<br>Menard |
| *C. rotunda* Croneis and Funkhouser, 1939 | — | — | — | — | Clore |
| *C. rotunda tumida* Croneis and Funkhouser, 1939 | — | — | — | — | Clore |
| *C. simulans* Croneis and Thurman, 1939 | — | — | — | — | Menard<br>Kinkaid |
| *C. spinosa* Croneis and Bristol, 1939 | — | — | — | — | Menard |
| *Cavellina coryella* Croneis and Gale, 1939 | — | — | — | — | Golconda |
| *C. glandella* (Whitfield), 1882 | — | — | Batesville<br>Salem<br>Warsaw | | |
| *C. hoeniri* Coryell and Johnson, 1939 | — | — | — | — | Clore |
| *C. ithunnae* Coryell and Johnson, 1939 | — | — | — | — | Clore |
| *C. mediocris* Croneis and Thurman, 1939 | — | — | — | — | Kinkaid |
| *C. ovalis* Croneis and Funkhouser, 1939 | — | — | — | — | Clore |
| *C. parallela* Croneis and Gutke, 1939 | — | — | — | — | Renault |
| *C. ? perplexa* Croneis and Funkhouser, 1939 | — | — | — | — | Clore<br>Menard |
| *C. spatulata* Croneis and Gutke, 1939 | — | — | — | — | Renault |
| *Ceratopleurina mimiri* Coryell and Johnson, 1939 | — | — | — | — | Clore |
| *Chesterella exuta* Croneis and Gutke, 1939 | — | — | — | — | Renault |
| *C. fissurata* Croneis and Gutke, 1939 | — | — | — | — | Renault |
| *Ctenobolbina loculata* Ulrich, 1900 | Ridgetop | | | | |
| *Cypridina acadia* Bell, 1929 | — | — | — | — | L. Windsor |
| *C. herzeri* Ulrich, 1891 | Waverly | Keokuk | | | |
| *Cythere crassimarginata* Winchell, 1862 | Waverly | | | | |
| *C. ohioensis* Herrick, 1888 | — | Keokuk | | | |
| *Cytherella bennei* Jones, Kirkby, and Brady, 1884 | — | — | — | Caney | |
| *C. bransoni* Morey, 1935 | — | Amsden | | | |
| *C. emaciata* Geis, 1932 | — | — | Salem | | |
| *C. geisei* Croneis and Gale, 1939 | — | — | — | — | Golconda |
| *C. gunnelli* Morey, 1935 | Basal Miss. | Chouteau | | | |
| *C. ovatiformis* Ulrich, 1891 | — | — | — | — | Glen Dean |
| *C. savagei* Geis, 1932 | — | — | Salem | | |
| *C. spergenensis* Geis, 1932 | — | — | Salem | | |
| *C. unioniformis* Herrick, 1891 | — | Cuyahoga | | | |
| *Deloia serrata* Croneis and Thurman, 1939 | — | — | — | — | Kinkaid |
| *D. spinosa* Croneis and Bristol, 1939 | — | — | — | — | Menard |
| *D. sulcata* Croneis and Funkhouser, 1939 | — | — | — | — | Clore |
| *Denisonia cincta* Croneis and Bristol, 1939 | — | — | — | — | Menard |
| *Discoidella pendens* Croneis and Gutke, 1939 | — | — | — | — | Renault |
| *D. simplex* Croneis and Gale, 1939 | — | — | — | — | Golconda |
| *Dizygopleura mehli* Morey, 1935 | Basal Miss. | Chouteau | | | |
| *Geffenina johnsoni* Coryell and Sohn, 1938 | — | — | — | — | Reynolds |
| *G. marmerae* Coryell and Sohn, 1938 | — | — | — | — | Reynolds |
| *Geffenites jungae* Coryell and Sohn, 1938 | — | — | — | — | Reynolds |
| *G. mammoidea* Coryell and Sohn, 1938 | — | — | — | — | Reynolds |
| *Gillina vitharri* Coryell and Johnson, 1939 | — | — | — | — | Clore |
| *Glyptopleura aduncа* Croneis and Thurman, 1939 | — | — | — | — | Kinkaid |
| *G. alata* Croneis and Funkhouser, 1939 | — | — | — | — | Clore |
| *G. alternata* Croneis and Funkhouser, 1939 | — | — | — | — | Clore |
| *G. angulata* Girty, 1910 | — | — | — | Fayetteville | |
| *G. bristoli* Croneis and Gutke, 1939 | — | — | — | — | Renault |
| *G. carinata* Geis, 1932 | — | — | Salem | | |
| *G. carroli* Croneis and Bristol, 1939 | — | — | — | — | Menard |
| *G. complexa* Croneis and Funkhouser, 1939 | — | — | — | — | Clore<br>Menard |

TABLE 1.—Continued

| | Kinderhookian | Osagian | Meramecan | Chesterian | |
|---|---|---|---|---|---|
| | | | | Lower | Upper |
| *G. compta* Croneis and Thurman, 1939 | — | — | — | — | Kinkaid |
| *G. conflexacostata* Croneis and Gale, 1939 | — | — | — | — | Golconda, Menard |
| *G. costata* (McCoy), 1844 | — | — | Warsaw | | |
| *G. ? curvata* Croneis and Gale, 1939 | — | — | — | — | Golconda |
| *G. decacostata* Croneis and Gale, 1939 | — | — | — | — | Golconda |
| *G. elegantis* Geis, 1932 | — | — | Salem | | |
| *G. elliptica* Croneis and Gutke, 1939 | — | — | — | — | Renault |
| *G. freyjae* Coryell and Johnson, 1939 | — | — | — | — | Clore |
| *G. friggae* Coryell and Johnson, 1939 | — | — | — | — | Clore |
| *G. gibba* Croneis and Gale, 1939 | — | — | — | — | Golconda |
| *G. harltoni* Croneis and Bristol, 1939 | — | — | — | — | Menard |
| *G. henbesti* Croneis and Gutke, 1939 | — | — | — | — | Renault |
| *G. hendricksi* Croneis and Gutke, 1939 | — | — | — | — | Renault |
| *G. humatilis* Croneis and Bristol, 1939 | — | — | — | — | Menard |
| *G. inopinata* Girty, 1910 | — | — | — | Fayetteville | |
| *G. intermedia* Croneis and Gale, 1939 | — | — | — | — | Golconda, Menard |
| *G. karli* Geis, 1932 | — | — | Salem | | |
| *G. kayi* Croneis and Bristol, 1939 | — | — | — | — | Menard |
| *G. kellettae* Croneis and Thurman, 1939 | — | — | — | — | Kinkaid |
| *G. multicostata* Morey, 1935 | — | Amsden | | | |
| *G. nerthusae* Coryell and Johnson, 1939 | — | — | — | — | Clore |
| *G. parvacostata* Geis, 1932 | — | — | Salem | | |
| *G. pentacostata* Croneis and Gale, 1939 | — | — | — | — | Golconda |
| *G. perbella* Geis, 1932 | — | — | Salem | | |
| *G. pergibba* Croneis and Gutke, 1939 | — | — | — | — | Renault |
| *G. pseudosulcata* Croneis and Thurman, 1939 | — | — | — | — | Kinkaid |
| *G. reniformis* Croneis and Thurman, 1939 | — | — | — | — | Kinkaid |
| *G. resupinata* Croneis and Bristol, 1939 | — | — | — | — | Menard |
| *G. sagae* Coryell and Johnson, 1939 | — | — | — | — | Clore |
| *G. salemensis* Coryell and Brackmier, 1931 | — | — | Salem | | |
| *G. schizopleura* Coryell and Sohn, 1938 | — | — | — | — | Reynolds |
| *G. similis* Croneis and Funkhouser, 1939 | — | — | — | — | Clore |
| *G. skathiae* Coryell and Johnson, 1939 | — | — | — | — | Clore |
| *G. symmetrica* Croneis and Funkhouser, 1939 | — | — | — | — | Clore |
| *G. tereliformis* Croneis and Thurman, 1939 | — | — | — | — | Kinkaid |
| *G. valkyriae* Coryell and Johnson, 1939 | — | — | — | — | Clore |
| *G. varians* Croneis and Funkhouser, 1939 | — | — | — | — | Clore |
| *G. varicostata* Croneis and Thurman, 1939 | — | — | — | — | Kinkaid |
| *G. venosa* (Ulrich), 1891 | — | — | — | — | Glen Dean |
| *Glyptopleurina ? bulbosa* Croneis and Gale, 1939 | — | — | — | — | Golconda |
| *G. complexa* Croneis and Bristol, 1939 | — | — | — | — | Menard |
| *G. coryelli* Croneis and Gutke, 1939 | — | — | — | — | Renault |
| *G. simplex* Croneis and Bristol, 1939 | — | — | — | — | Menard |
| *G. simulans* Croneis and Gutke, 1939 | — | — | — | — | Renault |
| *Glyptopleurites tyri* Coryell and Johnson, 1939 | — | — | — | — | Clore |
| *Glyptopleuroides girtyi* Croneis and Gutke, 1939 | — | — | — | — | Renault |
| *G. insculptus* Croneis and Gale, 1939 | — | — | — | — | Golconda |
| *G. perplexa* Croneis and Gutke, 1939 | — | — | — | — | Renault |
| *Golcondella sulcata* Croneis and Gale, 1939 | — | — | — | — | Golconda |
| *Graphiodactylus arkansanus* (Girty), 1910 | — | — | — | Fayetteville, Barnett | |
| *G. cornutus* (Ulrich and Bassler), 1932 | Ridgetop | Chouteau | | | |
| *G. granopunctatus* (Ulrich and Bassler), 1932 | Ridgetop | Chouteau | | | |
| *G. minutus* Morey, 1936 | — | Chouteau | | | |
| *G. spinosus* Morey, 1935 | Basal Miss. | Chouteau? | | | |
| *G. subquadratus* Morey, 1935 | Basal Miss. | | | | |
| *G. tumidus* Morey, 1935 | Basal Miss. | Chouteau? | | | |
| *G. waltheri* Morey, 1935 | Basal Miss. | Chouteau? | | | |
| *Halliella ? retiformis* Girty, 1910 | — | — | — | Fayetteville | |
| *Hastacypris bradyi* Croneis and Gutke, 1939 | — | — | — | — | Renault |
| *Healdia ampla* Roundy, 1926 | — | Boone | | | |
| *H. bluefieldana* Coryell and Sohn, 1938 | — | — | — | — | Reynolds |
| *H. decora* Morey, 1936 | — | Chouteau | | | |
| *H. fayettevillensis* Harlton, 1929 | — | — | — | Fayetteville | |
| *H. goniapleura* Croneis and Bristol, 1939 | — | — | — | — | Menard |
| *H. ? menardensis* Croneis and Bristol, 1939 | — | — | — | — | Menard |
| *H. opina* Croneis and Gale, 1939 | — | — | — | — | Golconda |
| *H. ornata* Morey, 1935 | — | Amsden | | | |
| *H. simplex* Roundy, 1926 | — | — | — | — | Reynolds |
| *H. subcarinata* Morey, 1935 | Basal Miss. | Amsden | | | |
| *H. triangularis* Croneis and Gale, 1939 | — | — | — | — | Golconda |
| *H. variolosa* Geis, 1932 | — | — | Salem | | |
| *H. vinitaensis* Harlton, 1929 | — | — | — | Fayetteville | |
| *Hollinella cestriensis* (Ulrich), 1891 | — | — | — | — | Glen Dean |
| *H. granifera* (Ulrich), 1891 | — | — | St. Louis | | |
| *H. moreyi* Croneis and Bristol, 1939 | — | — | — | — | Menard, Clore |
| *H. radiata* (Jones and Kirkby), 1867 | — | — | — | — | Clore |
| *H. simulatrix* (Ulrich), 1891 | — | — | — | — | Glen Dean |
| *H. typica* Morey, 1936 | — | Amsden | | | |

TABLE 1.—Continued

| | Kinderhookian | Osagian | Meramecan | Chesterian | |
|---|---|---|---|---|---|
| | | | | Lower | Upper |
| *Hypotetragona impolita* Morey, 1935 | Basal Miss. | Chouteau | | | |
| *Idiomorphina insignis* Croneis and Gale, 1939 | — | — | — | — | Golconda |
| *I. oehersi* Croneis and Bristol, 1939 | — | — | — | — | Menard |
| *I. ornata* Croneis and Gale, 1939 | — | — | — | — | Golconda |
| *Jonesina consimilis* Croneis and Bristol, 1939 | — | — | — | — | Menard |
| *J. holli* Croneis and Gutke, 1939 | — | — | — | — | Renault |
| *J. insculpta* Croneis and Funkhouser, 1939 | — | — | — | — | Clore |
| *J. intermedia* Croneis and Bristol, 1939 | — | — | — | — | Menard |
| *J. lalickeri* Croneis and Bristol, 1939 | — | — | — | — | Menard |
| *J. oblonga* Geis, 1932 | — | — | Salem | | |
| *J. odini* Coryell and Johnson, 1939 | — | — | — | — | Clore |
| *J. persulcata* Croneis and Gale, 1939 | — | — | — | — | Golconda |
| *J. puncta* Morey, 1935 | — | Amsden | — | — | Clore |
| *J. reticulata* Harlton, 1929 | — | — | — | Fayetteville | |
| *J. sinuodorsata* Geis, 1932 | — | — | Salem | — | |
| *J.? skinneri* Croneis and Gale, 1939 | — | — | — | — | Golconda |
| *J. spinosa* Croneis and Funkhouser, 1939 | — | — | — | — | Clore |
| *J.? tumida* Croneis and Thurman, 1939 | — | — | — | — | Kinkaid |
| *J. vinitaensis* Harlton, 1929 | — | — | — | Fayetteville | |
| *J. wrighti* Croneis and Gutke, 1939 | — | — | — | — | Renault |
| *Kellettella incarinata* Geis, 1932 | — | — | Salem | | |
| *Kirkbya aequalis* Croneis and Funkhouser, 1939 | — | — | — | — | Clore |
| *K. bifrons* Croneis and Thurman, 1939 | — | — | — | — | Kinkaid |
| *K. dorsoconvexa* Geis, 1932 | — | — | Salem | | |
| *K. fossula* Croneis and Bristol, 1939 | — | — | — | — | Menard |
| *K. intermedia* Croneis and Thurman, 1939 | — | — | — | — | Kinkaid |
| *K. marginata* Croneis and Funkhouser, 1939 | — | — | — | — | Clore |
| *K. regularis* Croneis and Gale, 1939 | — | — | — | — | Golconda |
| *K. rothi* Geis, 1932 | — | — | Salem | | |
| *K. symmetrica* Croneis and Thurman, 1939 | — | — | — | — | Kinkaid |
| *K. turrita* Croneis and Gale, 1939 | — | — | — | — | Golconda |
| *K. welleri* Geis, 1932 | — | — | Salem | | |
| *Kirkbyella ? dubia* Morey, 1936 | — | Chouteau | | | |
| *K. gutkei* Croneis and Bristol, 1939 | — | — | — | — | Menard |
| *K. osarkensis* Morey, 1936 | — | Chouteau | | | |
| *K. quadrata* Croneis and Gutke, 1939 | — | — | — | — | Renault |
| *K. scapha* Morey, 1935 | Basal Miss. | Chouteau | | | |
| *Kloedenella sigurdi* Coryell and Johnson, 1939 | — | — | — | — | Clore |
| *Kloedenellina heimdalli* Coryell and Johnson, 1939 | — | — | — | — | Clore |
| *Knightina neglecta* Croneis and Gale, 1939 | — | — | — | — | Golconda |
| *K. nodobliqua* Croneis and Gale, 1939 | — | — | — | — | Golconda |
| *K. pingnoides* Croneis and Gale, 1939 | — | — | — | — | Golconda |
| *Knoxina inflata* Croneis and Gale, 1939 | — | — | — | — | Golconda |
| *K. rogatsi* Croneis and Gutke, 1939 | — | — | — | — | Renault |
| *Lamarella thurmani* Croneis and Funkhouser, 1939 | — | — | — | — | Clore |
| *Leightonella torta* Croneis and Gale, 1939 | — | — | — | — | Golconda |
| *Leperditia juvensis* Croneis and Gale, 1939 | — | — | — | — | Golconda |
| *Lokius sigynae* Coryell and Johnson, 1939 | — | — | — | — | Clore |
| *Macrocypris biconcava* Croneis and Gutke, 1939 | — | — | — | — | Renault |
| *M. chapmani* Croneis and Bristol, 1939 | — | — | — | — | Menard |
| *M. reginni* Coryell and Johnson, 1939 | — | — | — | — | Clore |
| *Mauryella mammilata* Ulrich and Bassler, 1932 | Ridgetop | | | | |
| *M. quincollina* Harlton, 1929 | — | — | — | Fayetteville | |
| *Microcheilinella distorta* (Geis), 1932 | — | — | Salem | | |
| *M. pergracilis* Croneis and Gale, 1939 | — | — | — | — | Golconda |
| *M. spinosa* (Geis), 1932) | — | — | Salem | | |
| *M. subcorbuloides* (Jones and Kirkby), 1885 | — | — | — | Barnett | |
| *Microcoelonella scania* Coryell and Sohn, 1938 | — | — | — | — | Reynolds |
| *Microparaparchites inornatus* Croneis and Bristol, 1939 | — | — | — | — | Menard |
| *M. spinosus* Croneis and Gale, 1939 | — | — | — | — | Golconda, Menard |
| *Monoceratina furcula* Croneis and Gale, 1939 | — | — | — | — | Golconda |
| *M. tennesseense* Ulrich and Bassler, 1932 | Ridgetop | | | | |
| *Moorea granosa* Ulrich, 1891 | — | — | — | — | Glen Dean |
| *Neokloedenella prima* Croneis and Funkhouser, 1939 | — | — | — | — | Clore |
| *N. secunda* Croneis and Bristol, 1939 | — | — | — | — | Menard |
| *N. subquadrata* Croneis and Gutke, 1939 | — | — | — | — | Renault |
| *Nuferella wellsi* Coryell and Sohn, 1938 | — | — | — | — | Reynolds |
| *Oliganisus geisi* Croneis and Gutke, 1939 | — | — | — | — | Renault |
| *O. punctatus* Geis, 1932 | — | — | Salem | | |
| *O. sulcatus* Geis, 1932 | — | — | Salem | | |
| *Paraparchites carbonarius* (Hall), 1858 | — | — | Salem | | |
| *P. disjunctus* Morey, 1935 | Basal Miss. | Chouteau | | | |
| *P. gibbus* Bell, 1929 | — | — | — | — | L. Windsor |
| *P. inornatus* (McCoy), 1844 | — | — | — | — | Golconda, Renault, Menard |
| *P. kinkaidensis* Croneis and Thurman, 1939 | — | — | — | — | Kinkaid |
| *P. nicklesi* (Ulrich), 1891 | Basal Miss. | Chouteau, Amsden | Moorfield, Batesville, Warsaw | Fayetteville | Clore, Glen Dean |

TABLE 1.—Continued

| | Kinderhookian | Osagian | Meramecan | Chesterian | |
|---|---|---|---|---|---|
| | | | | Lower | Upper |
| *P. nicklesi cyclopea* Girty, 1910 | — | — | — | Fayetteville | |
| *P. robustus* Croneis and Gutke, 1939 | — | — | — | — | Renault |
| *P. subcircularis* Geis, 1932 | — | — | Salem | | |
| *Perprimitia ? bicornis* Croneis and Gale, 1939 | — | — | — | — | Golconda |
| *P. elegans* Croneis and Gutke, 1939 | — | — | — | — | Renault |
| *P. funkhouseri* Croneis and Thurman, 1939 | — | — | — | — | Kinkaid |
| *P. matheri* Croneis and Bristol, 1939 | — | — | — | — | Menard |
| *P. robusta* Croneis and Gale, 1939 | — | — | — | — | Golconda |
| *P. spinosa* Croneis and Gale, 1939 | — | — | — | — | Golconda |
| *P. turrita* Croneis and Gutke, 1939 | — | — | — | — | Renault |
| *Persansabella bradfieldi* Coryell and Sohn, 1938 | — | — | — | — | Reynolds |
| *P. harrisi* (Croneis and Funkhouser), 1939 | — | — | — | — | Clore |
| *P. johnsoni* (Croneis and Thurman), 1939 | — | — | — | — | Kinkaid / Menard |
| *P. njorthi* (Coryell and Johnson), 1939 | — | — | — | — | Clore |
| *P. reversa* (Morey), 1935 | — | Amsden | — | — | Clore |
| *Plagionephrodes marginata* Morey, 1935 | Basal Miss. | Chouteau | | | |
| *P. uninodosus* Morey, 1935 | Basal Miss. | Chouteau | | | |
| *Pontocypris ? acuminata* Ulrich, 1891 | L. Waverly | | | | |
| *P. bassleri* Morey, 1935 | Basal Miss. | Chouteau | | | |
| *P. billingsella* Geis, 1932 | — | — | Salem | | |
| *P. coryelli* Geis, 1932 | — | — | Salem | | |
| *Primitia cestriensis* Ulrich, 1891 | — | — | — | — | Glen Dean |
| *P. cestriensis caldwellensis* Ulrich, 1891 | — | — | — | — | Glen Dean |
| *P. fayettevillensis* Girty, 1910 | — | — | — | Fayetteville | |
| *P. granimarginata* Ulrich, 1891 | — | — | — | — | Glen Dean |
| *P. moorefieldana* Girty, 1911 | — | Boone | Moorefield | | |
| *P. semisalis* Girty, 1910 | — | — | Moorefield / Batesville | Fayetteville | |
| *P. simulans* Ulrich, 1891 | — | — | — | | Glen Dean |
| *P. subequata* Ulrich, 1891 | — | — | — | — | Clore |
| *Primitiopsis ? striatus* Croneis and Funkhouser, 1939 | — | — | — | — | Clore |
| *Pseudoparaparchites ? aclis* Croneis and Thurman, 1939 | — | — | — | — | Kinkaid |
| *Pterocedella inconsueta* Croneis and Gutke, 1939 | — | — | — | — | Renault |
| *P. mirabilis* Croneis and Gale, 1939 | — | — | — | — | Golconda |
| *Sansabella amsdenensis* Morey, 1935 | — | Amsden | | — | |
| *S. ? dubia* Morey, 1935 | — | Amsden | | | |
| *S. fenriri* Coryell and Johnson, 1939 | — | — | — | | Clore |
| *S. gunnari* Coryell and Johnson, 1939 | — | — | — | — | Clore |
| *S. inflata* Geis, 1932 | — | — | Salem | — | |
| *S. sulcata* Roundy, 1926 | — | — | — | | |
| *S. tumida* Coryell and Sohn, 1938 | — | — | — | Barnett | Reynolds |
| *S. unicornis* (Girty), 1915 | — | — | — | — | |
| *S. whitei* Bradfield, 1935 | — | — | — | Caney | Reynolds |
| *Sargentina allani* Coryell and Johnson, 1939 | — | — | — | — | Clore |
| *S. forsetii* Coryell and Johnson, 1939 | — | — | — | — | Clore |
| *Savagella lindahli* (Ulrich), 1891 | — | Boone | Salem / Warsaw / Batesville | — / Barnett | |
| *S. rhomboidalis* (Girty), 1915 | — | — | — | | |
| *Seminolites conspicuus* Harlton, 1929 | — | — | — | | |
| *S. sohni* Croneis and Bristol, 1939 | — | — | — | Fayetteville | Menard |
| *Silenites marginiferus* (Geis), 1932 | — | Chouteau | Salem | — | |
| *S. warei* Morey, 1936 | — | Chouteau | | | |
| *Sulcella crassimarginata* Croneis and Thurman, 1939 | — | — | — | | Kinkaid |
| *S. decora* Morey, 1935 | Basal Miss. | Chouteau | | — | |
| *Ulrichia emarginata* Ulrich, 1891 | — | — | — | | Glen Dean |
| *U. tenuimuralis* Ulrich and Bassler, 1932 | Ridgetop | | | — | |
| *Verrucosella golcondensis* Croneis and Gale, 1939 | — | — | — | | Golconda / Menard |
| *Waylandella perplexa* Morey, 1935 | Basal Miss. | Chouteau | | — | |
| *Workmanella distincta* Croneis and Gale, 1939 | — | — | — | | Golconda |
| *Youngiella rhomboidalis* Croneis and Bristol, 1939 | — | — | — | — | Menard |

Total genera, 82.
Total species, 364.

## REFERENCES


BASSLER, R. S., *1932*, The stratigraphy of the Central Basin of Tennessee. *Tennessee Geol. Survey, Bull.*, 38, pl. 27, figs. 1–14.

BASSLER, R. S., *1935*, Description of Paleozoic fossils from the Central Basin of Tennessee. *Washington Acad. Sci., Jour.*, vol. 25, no. 9, pp. 403–409.

BELL, W. A., The Horton-Windsor District, Nova Scotia. *Canada Geol. Survey, Memoir* 155, p. 185, pl. 34, figs. 5, 6.

CORYELL, H. N. and BRACKMIER, G., *1931*, The Ostracode Genus Glyptopleura. *Am. Midland Naturalist*, vol. 12, no. 12, pp. 505–532.

CORYELL, H. N. and JOHNSON, S. C., *1939*, Ostracoda of the Clore Limestone, Upper Mississippian, of Illinois. *Jour. Paleontology*,

vol. 13, no. 2, pp. 214–224, pls. 25, 26.
CORYELL, H. N. and SOHN, I. G., *1938*, Ostracoda from the Mauch Chunk (Mississippian) of West Virginia. *Jour. Paleontology*, vol. 12, no. 6, pp. 596–603, pl. 69.
CRONEIS, C. and BRISTOL, H. M., *1939*, New Ostracodes from the Menard Formation. *Denison Univ., Sci. Lab., Bull.*, vol. 34, pp. 65–102, pls. 3, 4.
CRONEIS, C. and FUNKHOUSER, H. J., *1939*, New Ostracodes from the Clore Formation. *Denison Univ., Sci. Lab., Bull.*, vol. 33, pp. 331–360, pls. 9, 10.
CRONEIS, C. and GALE, S., *1939*, New Ostracodes from the Golconda Formation. *Denison Univ., Sci. Lab., Bull.*, vol. 33, pp. 251–295, pls. 5, 6.
CRONEIS, C. and GUTKE, R. L., *1939*, New Ostracodes from the Renault Formation. *Denison Univ., Sci. Lab., Bull.*, vol. 34, pp. 33–63, pls. 1, 2.
CRONEIS, C. and THURMAN, F. A., *1939*, New Ostracodes from the Kinkaid Formation. *Denison Univ., Sci. Lab., Bull.*, vol. 33, pp. 297–330, pls. 7, 8.
GEIS, H. L., *1932*, Some Ostracodes from the Salem Limestone, Mississippian, of Indiana. *Jour. Paleontology*, vol. 6, no. 2, pp. 149–188, pls. 22–26.
GIRTY, G. H., *1909*, Fauna of the Caney Shale of Oklahoma. *U. S. Geol. Survey, Bull.* 377, p. 72, pl. 5, figs. 7, 8.
GIRTY, G. H., *1910*, New Genera and Species of Carboniferous Fossils from the Fayetteville Shale of Oklahoma. *New York Acad. Sci. Annals*, vol. 20, no. 3, pt. 2, pp. 189–238 (no figures).
GIRTY, G. H., *1911*, Fauna of the Moorefield Shale of Arkansas. *U. S. Geol. Survey, Bull.* 439, pp. 105–106, pl. 9, figs. 2–7.

MANUSCRIPT RECEIVED BY EDITOR, DEC. 2, 1939.

GIRTY, G. H., *1915*, Fauna of the Batesville Sandstone of Northern Arkansas. *U. S. Geol. Survey, Bull.* 593, pp. 134–137, pl. 11, figs. 2, 3.
GIRTY, G. H., *1915*, Fauna of the so-called Boone Chert of Batesville, Arkansas. *U. S. Geol. Survey, Bull.* 595, pp. 39–40, pl. 11, fig. 10.
HARLTON, B. H., *1929*, Some Upper Mississippian (Fayetteville) and Lower Pennsylvanian (Wapanucka-Morrow) Ostracoda of Oklahoma and Arkansas. *Am. Jour. Sci.*, 5th ser. vol. 18, no. 105, pp. 254–270, pls. 1, 2.
HERRICK, C. L., *1891*, The Cuyahoga shale and the problem of the Ohio Waverly. *Geol. Soc. America, Bull.*, vol. 2, pp. 31–48, pl. 1, figs. 8–10.
MOREY, Ph. S., *1935a*, Ostracoda from the Basal Mississippian Sandstone in Central Missouri. *Jour. Paleontology*, vol. 9, no. 4, pp. 316–326, pl. 28.
MOREY, Ph. S., *1935b*, Ostracoda from the Amsden Formation of Wyoming. *Jour. Paleontology*, vol. 9, no. 6, pp. 474–482, pl. 54.
MOREY, Ph. S., *1936*, Ostracoda from the Chouteau Formation of Missouri. *Jour. Paleontology*, vol. 10, no. 2, pp. 114–122, pl. 19.
ROUNDY, P. V., *1926*, Mississippian Formations of San Saba County, Texas. *U. S. Geol. Survey Prof. Paper*, 146, pt. 2, pp. 5–8, pl. 1.
ULRICH, E. O., *1891*, New and Little Known American Paleozoic Ostracoda. *Cin. Soc. Nat. Hist., Jour.*, vol. 13, pp. 200–211, pls. 12, 14, 17, 18.
WHITE, C. A. and ST. JOHN, *1867*, Preliminary notice of new genera and species of fossils. *Iowa Geol. Survey*, Prelim. Notes, p. 147.
WHITFIELD, R. P., *1882*, On the Fauna of the Lower Carboniferous limestone of Spergen Hill, Indiana. *Am. Mus. Nat. History, Bull.* 1, no. 3, p. 94, pl. 9, figs. 24–29.

## ATURIA IN THE UPPER MIOCENE OF JAVA[1]

J. WYATT DURHAM
Department of Paleontology, University of California, Berkeley, California

WHILE engaged in geological investigations in West Java, the author collected two fragmentary specimens of *Aturia* in clay shales belonging to the "Middle Bodjongmanik beds." This formation generally is considered as belonging to the lower part of the Upper Miocene (stage $n_3$ of the Netherlands Indies Geological Survey).

As *Aturia* has not previously been reported inside the triangle India-Australia-Japan, it is deemed worthy of recording the occurrence despite the poor preservation of the specimens found.

These specimens were submitted to Dr. L. F. Spath of the British Museum for examination. He reports:[2]

I have compared the two specimens of *Aturia* you sent with the material in this museum and I think that your specimen no. 1 may well be identified with *A. aturi*, Basterot, from the European Miocene, at least if we rely on the section of the inner whorls. Specimen 2 has a wider venter, as

[1] Published by permission of the Nederlandsche Pacific Petroleum Maatschappij.

[2] Personal communication, September 28, 1938.

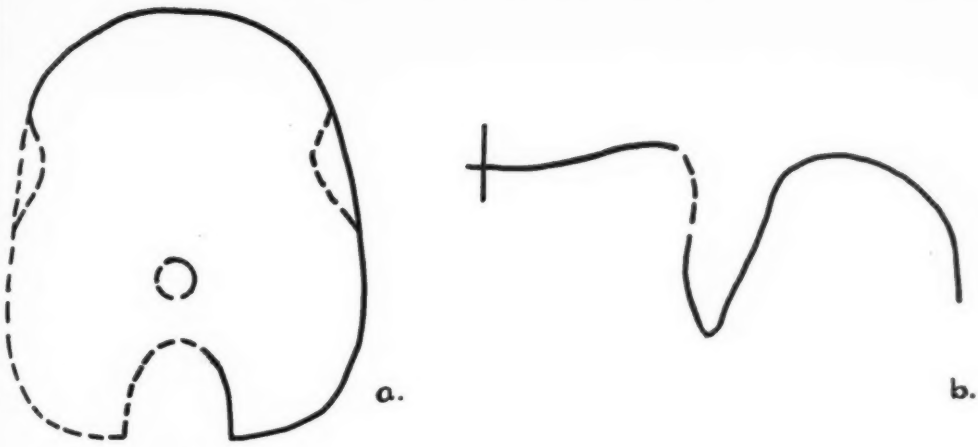



FIG. 1.—*Aturia* sp., drawn from specimen no. 2, approximately ×1. *a*, Whorl section, partly restored; *b*, trace of suture pattern.

your sketch shows, but it is probably only a local variety.

Text figure 1 is a restoration from photographs of the whorl outline and the external suture of specimen no. 2 which consists of only slightly over a single chamber of the last volution of an individual which was probably about 90 mm in diameter. Specimen no. 1 is more complete but in a bad state of preservation. These have been deposited in the Paleontological Museum of the Dienst van den Mijnbouw, Bandoeng, Java, N. E. I.

Specimen no. 1 (*Aturia aturi* Basterot) comes from an outcrop of dark gray black shale on the bank of a small stream tributary to the Tjipangaoer, 2 kilometers slightly north of east of Kampong Pandjingdangan, 8 kilometers due north of Djasinga, West Java.

Specimen no. 2 was found in an outcrop of dark blue grey shale on the bank of the stream Tjibioek, 1½ kilometers above its junction with the Tjipangaoer, 4½ kilometers due north of Djasinga, West Java.

Specimen no. 1 (*Aturia aturi* Basterot) occurs somewhat higher in the section than specimen no. 2 which is overlain by beds containing *Lepidocyclina*, *Cultellus dilatatus* Martin, *Rostellaria verbeeki* Martin, *Cyprea caput-viperae* Martin and other fossils characteristic of the Upper Miocene.

MANUSCRIPT RECEIVED BY EDITOR, NOV. 21, 1939.

## AN OCCURRENCE OF ISOTELUS GIGAS DEKAY IN THE ARBUCKLE MOUNTAINS, OKLAHOMA

ALFRED R. LOEBLICH, JR.
Walker Museum, University of Chicago, Chicago, Illinois

RECENTLY Laudon (1938, p. 283; 1939, p. 211) reported an unusual occurrence of *Isotelus gigas* DeKay from the Bromide formation of the Criner Hills, Oklahoma. Decker earlier (1931, p. 83) discovered the stratum and, although he did not describe it in detail, listed it in his measured section for the Criner Hills.

During the summer of 1938, while measuring sections and collecting Bryozoa in the Bromide formation with Dr. C. E. Decker, the writer discovered a similar occurrence of *Isotelus gigas* DeKay on Spring Creek (NE ¼, Sec. 17, T. 2 S., R. 1 W.) in the southwestern portion of the Arbuckle Mountains.

The trilobites are exposed for a distance

of approximately 50 feet along the strike in the middle of a limestone layer, two to three inches in thickness. The stratum is one of a series of alternating thin shales and argillaceous limestones, approximately 140 feet below the top of the Bromide formation. Numerous bryozoans, brachiopods and sponges are present in the beds immediately above and below the trilobite layer.

The trilobites, which are brown in color against a light gray background, make striking museum specimens. Like those at the Criner Hill locality the specimens are badly fractured by weathering and are difficult to prepare. Only one small slab was noticed in which the trilobites had weathered out. As in the Criner Hills occurrence, approximately half of the specimens are imbedded with the venter exposed, thus revealing many hypostomes in position.

MANUSCRIPT RECEIVED BY EDITOR, OCT. 24, 1939.

The similarity in preservation and abundance of the trilobites, as well as the stratigraphic similarities suggest a correlation of the beds in the two areas.

Small slabs from the Arbuckle locality are in the collections at Walker Museum, University of Chicago; the University of Oklahoma, Norman, Oklahoma, and in Knox College, Galesburg, Illinois.

REFERENCES

DECKER, C. E., and MERRITT, C. A., *1931*, The stratigraphy and physical characteristics of the Simpson Group: *Okla. Geol. Survey, Bull.* 55, p. 83.

LAUDON, L. R., *1938*, Abundant occurrence of *Isotelus giges* DeKay in the South Criner Hills of Oklahoma: *Geol. Soc. America, Proc. for 1937*, p. 283.

——, *1939*, Unusual occurrence of *Isotelus gigas* DeKay in the Bromide formation (Ordovician) of southern Oklahoma: *Jour. Paleontology*, vol. 13, no. 2, pp. 211–213.

## MEGASCOPIC FOSSILS FROM THE PERMIAN REEF TREND OF WEST TEXAS AND NEW MEXICO

JOHN M. HILLS
Midland, Texas[1]

MEGASCOPIC fossils are relatively uncommon in cores from the Upper Permian of West Texas and New Mexico. Therefore, special interest attaches to two rather well preserved specimens found in cores taken from wells drilled near the Upper Permian Capitan reef.

The first is from the Rowan No. 1 Elliot, Sec. 17 R. 37 E. T. 22 S., Lea County, New Mexico at a depth of 3871 feet. This well is a number of miles east, or back, of the late Capitan reef front. From subsurface correlation, the core probably is early Capitan or late Grayburg in age. This specimen was sent to Dr. C. O. Dunbar of Yale University who reports in a letter of February 15, 1939 as follows:

> The brachiopod is the posterior part of a dorsal valve of one of the Orthotetinae. It is very close, if not identical, with *Orthotetes guadalupensis* Girty which was described from the Capitan limestone. Girty emphasized that the distinctive features of that species were the extreme fineness of the ribs and the lack of fasciculation which is so common in this family. The specimen you sent is somewhat larger than the types and is so incomplete as to leave the identification somewhat uncertain, but the shape appears to be right and the ribs are extremely fine and even as they were described by Girty.

The other specimen, a gastropod mold, came from the Amerada No. 2 Leck, Sec. 3, Block 74, Public School Lands, Winkler County, Texas. This well is immediately back of the reef. The core came from 3117 feet, probably at about the transition between the bedded Carlsbad and the true Capitan reef limestone.

This specimen was sent, with the New Mexico brachiopod, to Dr. Dunbar who forwarded a squeeze of it to Dr. J. Brookes Knight of Princeton for study. Dr. Knight reported:

> I have examined the squeeze and compared it carefully with squeezes from the Whitehorse gastropods. Subject only to some imperfections in preservation of surface details, I do not hesitate to identify the specimen as belonging to *Murchisonia gouldii* Beede.

[1] Published by permission of the Amerada Petroleum Corporation.

This note is written with the intention of putting these data on record, and it is perhaps out of place to draw any inferences. Nevertheless, it is particularly noteworthy to record the presence of a Whitehorse fossil in limestone which seems to be definitely of Capitan age.

## NEW NAMES FOR WECHES OSTRACODA

A. H. SUTTON AND JOHN R. WILLIAMS
University of Illinois, Urbana, Illinois

DR. MORTON B. STEPHENSON, Louisiana State University, and Dr. H. N. Coryell, Columbia University have called attention to certain taxonomic irregularities in a recent paper by Sutton and Williams (1939). These involve two cases of homonymy, and the genotype of *Cytherella*. We (1939, p. 569) proposed the name *subovata* for a species of *Cytheridea*. This name was used by Ulrich and Bassler (1904, p. 124) for a Maryland Miocene species, which was later reported from the *Arca* zone of the Choctawhatchee formation of the Miocene of Florida by Howe et al. (1935, p. 11) and from the Florida Miocene by Stephenson (1938, p. 134). We are herein changing the name to *Cytheridea* (*Haplocytheridea*) *bastropensis* Sutton and Williams. We also proposed the name *spinosa* for a species of *Cythereis* (1939, p. 563). This name is preoccupied by Lienenklaus (1900, p. 516). We are changing it to *Cythereis wechesensis* Sutton and Williams. Alexander (1929, p. 47), whom we followed, was in error in selecting *Cythere compressa* Münster as the genotype of *Cytherella* because Ulrich (1894, p. 684) previously had designated *Cytherina ovata* F. A. Roemer as the genotype.

### REFERENCES

ALEXANDER C. I., *1929*, Ostracoda of the Cretaceous of North Texas: *Texas Univ. Bull.* 2907.

HOWE, HENRY V. et al., *1935*, Ostracoda of the Arca zone of the Choctawhatchee Miocene of Florida: *Florida Dept. Conserv., Bull.* 13.

LIENENKLAUS, E., *1900*, Die Tertiär-Ostrakoden des mittleren Norddeutschlands: *Deutsche geol. Gesell. Zeitschr.*, vol. 52, pp. 497–550.

STEPHENSON, MORTON B., *1938*, Miocene and Pliocene Ostracoda of the genus *Cytheridea* from Florida: *Jour. Paleontology*, vol. 12, no. 2, pp. 127–148.

SUTTON, A. H. and WILLIAMS, JOHN R., *1939*, Ostracoda from the Weches formation at Smithville, Texas: *Jour. Paleontology*, vol. 13, no. 6, pp. 461–574.

ULRICH, E. O., *1894*, The Lower Silurian Ostracoda of Minnesota: *The Geology of Minnesota*, vol. 3, pt. 2, pp. 629–693.

ULRICH, E. O. and BASSLER, R. S., *1904*, Ostracoda: *Maryland Geol. Survey, Miocene*, pp. 98–130.

## CALIFORNIA CRETACEOUS MOLLUSKS, CORRECTION

W. P. POPENOE
California Institute of Technology, Pasadena, Calif.

IN JULY, 1937 (Popenoe, 1937, p. 394), I proposed a new pelecypod genus *Calva* to include several Cretaceous venerid species, including "*Venus*" *varians* Gabb and "*Meretrix*" *nitida* Gabb of the Upper Cretaceous of California and "*Meretrix*" *umzambiensis* Woods from the Upper Cretaceous of Pondoland, east Cape Province, South Africa. I have since learned that *M. umzambiensis* Woods is the genotype of *Trigonocallista* Rennie (1930). Dr. Rennie has examined specimens of *Calva regina* Popenoe, genotype of *Calva*, which I sent to him, and confirms my opinion that *C. regina* and *Trigonocallista umzambiensis* (Woods) are congeneric. *Calva* Popenoe, 1937, therefore is a synonym of *Trigonocallista* Rennie, 1930.

Under the discussion of *Turritella iota* in the same paper (Popenoe, 1937, p. 401), I referred to *Turritella whiteavesi* Anderson and Hanna. This reference is an error and should be *Turritella parallela* Anderson and Hanna (1935).

### REFERENCES

ANDERSON, F. M., and HANNA, G. D., *1935*, *California Acad. Sci., Proc.*, 4th. ser., vol. 23, p. 26, pl. 9, figs. 1–3.

POPENOE, W. P., *1937*, Upper Cretaceous Mollusca from southern California: *Jour. Paleontology*, vol. 11, no. 5, pp. 379–402.

RENNIE, J. V. L., *1930*, *South African Mus., Annals*, vol. 28, p. 197.

# SOCIETY RECORDS AND ACTIVITIES

## MEMBERS OF THE SOCIETY OF ECONOMIC PALEONTOLOGISTS AND MINERALOGISTS

*ADAMS, BRADFORD C., 929 South Broadway, Los Angeles, California

ADAMS, JOHN EMERY, Standard Oil Company of Texas, Drawer R, Midland, Texas

ADKINS, W. S., Shell Oil Company, Inc., Shell Building, Houston, Texas

ALBRITTON, CLAUDE C., JR., Department of Geology, Southern Methodist University, Dallas, Texas

ALEXANDER, C. I., Geology Department, Magnolia Petroleum Company, Tyler, Texas

ANDERSON, FRANK MARION, 58 Hillcrest Road, Berkeley, California

ANDREWS, T. G., University of Alabama, Box 2005, University, Alabama

*APPLIN, ESTHER R., 2212 Mistletoe, Fort Worth, Texas

ARELLANO, A. R. V., Cia. Mex. de Pet. "El Aguila" S. A., Apt. 150, Tampico, Tamps., Mexico

ARICK, MILLARD B., Lago Petroleum Corporation, Apt. 172, Maracaibo, Venezuela, S. A.

ARTUSY, RAY, 1831 Branard, Houston, Texas

BAKER, WILLIAM A., JR., 3218 Ewing St., Houston, Texas

*BALL, JOHN RICE, Department of Geology, Northwestern University, Evanston, Illinois

BARBAT, WILLIAM F., c/o Standard Oil Company, Bin XX, Taft, California

*BARKER, R. WRIGHT, Shell Oil Company, Inc., Shell Building, Houston, Texas

*BARNES, SYDNEY U., Standard Oil Company of Egypt, 22 Sharia Kasr el Nil, Cairo, Egypt

*BASSLER, R. S., U. S. National Museum, Washington, D. C.

*BECK, R. STANLEY, El Tejon Hotel Annex, Bakersfield, California

BENNETT, ETHEL EVANS, 4903 Bryce Avenue, Fort Worth, Texas

BENTZ, ALFRED, Institution of Petroleum Geology, Invalidenstr. 44, Berlin N 4, Germany

*BERMUDEZ, PEDRO J., Museo-Poly, University of Havana, Havana, Cuba

*BERNARD, H. ALLEN, Department of Geology, Louisiana State University, University, Louisiana

BERNOULLI, W., 57 Sissacherstrasse, Basle, Switzerland

*BOWLES, EDGAR O., State Geological Survey, University, Alabama

BRADFIELD, H. H., The Texas Company, Box 1720, Fort Worth, Texas

BRADISH, BEVERLY B., Box 1502, Billings, Montana

BRANSON, E. B., Department of Geology, Missouri University, Columbia, Missouri

BRAUNSTEIN, JULES, Paleontological Section, Shell Oil Company, Inc., Houston, Texas

BREHM, CLARENCE E., Kingwood Oil Company, Effingham, Illinois

*BRIDGES, ROBERT C., School of Geology, Louisiana State University, University, Louisiana

*BRISTOL, HUBERT M., 814 Fair Oaks Avenue, Oak Park, Illinois

BROUGHTON, M. N., The Texas Company, Box 951, Houma, Louisiana

*BROWN, IDA A., Department of Geology, University of Sydney, Sydney, New South Wales, Australia

CALAHAN, L. W., The Texas Company, Box 457, New Iberia, Louisiana

*CALDWELL, LOREN A., Northern Illinois State Teachers College, DeKalb, Illinois

CAMPBELL, ROBERT B., Peninsular Oil and Refining Company, 602 Wallace S. Building, Tampa, Florida

CANFIELD, CHARLES R., 1925 W. 43d Street, Los Angeles, California

CAYLOR, GARTH W., Shell Oil Company, Inc., Centralia, Illinois

CHAMBERS, JACK, Phillips Petroleum Company, 521 Esperson Building, Houston, Texas

*CHELF, CARL, Texas Memorial Museum, Austin, Texas

CHENEY, M. G., Anzac Oil Corporation, Box 446, Coleman, Texas

CHURCH, CLIFFORD C., Tide Water Associated Oil Company, 79 New Montgomery Street, San Francisco, California

CLARK, BRUCE L., Museum of Paleontology,

University of California, Berkeley, California

CLARK, J. W., Magnolia Petroleum Company, Box 900, Dallas, Texas

CLIFTON, R. L., 1703 E. Maple Street, Enid, Oklahoma

COHEE, GEORGE V., State Geological Survey, Urbana, Illinois

COLE, J. GORDON, 3221 Hopkins Street, Oakland, California

*COOMBS, HOWARD A., University of Washington, 112 Johnson Hall, Seattle, Washington

CORYELL, HORACE N., Columbia University, New York, N. Y.

COX, BEN BURTON, Socony-Vacuum Oil Company, 26 Broadway, New York, N. Y.

CRAM, IRA H., Pure Oil Company, Box 271, Tulsa, Oklahoma

CRONEIS, CAREY, Museum of Paleontology, University of Chicago, Chicago, Illinois

CRUSE, JOHN S., JR.. Amerada Petroleum Corporation, Houston, Texas

CUSHMAN, JOSEPH A., 76 Brook Road, Sharon, Massachusetts

DECKER, CHARLES E., Department of Geology, University of Oklahoma, Norman, Oklahoma

DEGOLYER, E., 611 Continental Building, Dallas, Texas

*DENHAM, RICHARD L., Humble Oil and Refining Company, Midland, Texas

DEUSSEN, ALEXANDER, 1006 Shell Building, Houston, Texas

DICKERSON, ROY E., Atlantic Refining Company, 260 S. Broad Street, Philadelphia, Pennsylvania

DONOGHUE, DAVID, 1116 Fort Worth National Bank Building, Fort Worth, Texas

DORR, JAMES BRYAN, Shell Oil Company, Inc., Box 2099, Houston, Texas

*DREYER, FRANK E., Union Oil Company of California, Orcutt, California

DRIVER, HERSCHEL L., 630 West Palm Drive, Glendale, California

*DUNBAR, CARL O., Peabody Museum, Yale University, New Haven, Connecticut

DURGAN, HERBERT L., Sun Oil Company, Beaumont, Texas

DURHAM, J. WYATT, Department of Paleontology, University of California, Berkeley, California

*DUSENBURY, A. N., Iraq Petroleum Company, Ltd., Arrapha Camp, Kirkuk, Iraq

EDWARDS, EVERETT C., General Petroleum Corporation, Higgins Building, Los Angeles, California

*EDWARDS, KENNETH L., 736 Forest Avenue, Palo Alto, California

ELLIS, ALBERT D., Stanolind Oil and Gas Company, Box 3092, Houston, Texas

*ELLIS, BROOKS FLEMING, Department of Geology, New York University, New York, N. Y.

ELLISOR, ALVA C., Humble Oil and Refining Company, Drawer D, Houston, Texas

*EMEIS, J. D., Compania Petroleo de Shell, Bogota, Colombia, S. A.

*EMERY, KENNETH O., 1105 S. Douglas, Urbana, Illinois

FABIANI, RAMIRO, Instituto e Museo di Geologia, Della R., Universita di Palermo, Palermo, Italy

FERGUSON, GLENN C., Union Oil Company of California, Bakersfield, California

FERGUSON, H. C., 415 Esperson Building, Houston, Texas

FETTKE, CHARLES R., 1118 Wightman, Pittsburgh, Pennsylvania

*FISHER, LLOYD W., 59 Franklin Street, Lewiston, Maine

FLAGLER, C. W., Danish-American Prospecting Company, Nøore Alle 44, Aarhus, Denmark

*FRANKLIN, ELMER S., 2800 North Sichel Street, Los Angeles, California

FRINK, JOHN W., 424 Riddle Road, Cincinnati, Ohio

*FRITZ, EDWARD B., Union Oil Company, Box 511, Compton, California

*FRYE, JOHN C., U. S. Geological Survey, University of Kansas, Lawrence, Kansas

FUNKHOUSER, HAROLD J., Apt. 45, Puerta La Cruz, Venezuela, S. A.

GALE, ARTHUR S., 4118 Swarthmore, Houston, Texas

GALLOWAY, JESSE J., Department of Geology, Indiana University, Bloomington, Indiana

GARDNER, JULIA, U. S. Geological Survey, Washington, D. C.

GARRETT, J. B., JR., Stanolind Oil and Gas Company, Box 3092, Houston, Texas

GETZENDANER, F. M., 423 N. Park Street, Uvalde, Texas

GILES, ALBERT W., Department of Geology,

University of Arkansas, Fayetteville, Arkansas

GILL, J. P., Sinclair Prairie Oil Company, Box 978, Ardmore, Oklahoma

GILLULY, JAMES, Department of Geology, University of California, Los Angeles, California

GLENN, LEONIDAS C., Department of Geology, Vanderbilt University, Nashville, Tennessee

*GOOCH, D. D., Gulf States Exploration Company, 906 Carondelet Building, New Orleans, Louisiana

GOODRICH, PAUL K., 2500 Esperson Building, Houston, Texas

GOUDKOFF, PAUL P., 799 Subway Terminal Building, Los Angeles, California

GRANT, U. S., IV, Department of Geology, University of California, Los Angeles, California

GRAVELL, DONALD W., 2309 Huldy Street, Houston, Texas

GREENE, FRANK C., 900 East 9th Street, Kansas City, Missouri

GRIGSBY, R. B., Stanolind Oil and Gas Company, 1521 Charleston Avenue, Mattoon, Illinois

GRILEY, HORACE L., Sun Oil Company, Box 1348, Tulsa, Oklahoma

GRIMSDALE, T. F., c/o U. B. O. T., Ltd., Point Fortin, Trinidad, B. W. I.

GULLY, PHILLIP D., Box 1024, Beeville, Texas

HADLEY, WADE H., JR., Pure Oil Company, Box 1411, Baton Rouge, Louisiana

HALBOUTY, M. T., Merit Oil Corporation, Shell Building, Houston, Texas

HALSTED, MORRIS E., Amerada Petroleum Corporation, Houston, Texas

HAMILL, JAMES M., The Texas Company, 929 South Broadway, Los Angeles, California

HAMILTON, C. E., 1916 North Drexel, Oklahoma City, Oklahoma

HAMILTON, ROBERT G., 910 Philtower Building, Tulsa, Oklahoma

HANNA, G. DALLAS, California Academy of Sciences, San Francisco, California

HANNA, MARCUS A., Gulf Oil Corporation, Box 2100, Houston, Texas

HARLTON, BRUCE H., Amerada Petroleum Corporation, Box 2040, Tulsa, Oklahoma

HARRIS, REGINALD W., Department of Geology, University of Oklahoma, Norman, Oklahoma

HAWKINS, GLENN D., 423 South Allegheny, Tulsa, Oklahoma

*HAWKINS, HAROLD H., 235 George Mason Drive, Apt. 4, Arlington, Virginia

HAZZARD, ROY T., Box 1731, Shreveport, Louisiana

HEDBERG, HOLLIS D., Mene Grande Oil Company, Apartado 45, Barcelona, Venezuela, S. A.

HENBEST, LLOYD G., U. S. National Museum, Washington, D. C.

*HENDRICKS, JOHN A., 6796 Milner Road, Hollywood, California

*HESSE, CURTIS J., Texas Agricultural and Mechanical College, College Station, Texas

*HIBBARD, RAYMOND R., 219 Bissell Avenue, Buffalo, New York

†HILL, ROBERT T., Hotel Jefferson, Dallas, Texas

HOCKMAN, JAMES N., 327 North 3d Street, Apt. 3, Effingham, Illinois

HONESS, CHARLES W., Gulf Refining Company, Box 594, Owensboro, Kentucky

HOOVER, W. F., 300 South 19th Street, Mt. Vernon, Illinois

HORNBERGER, JOSEPH, JR., 2240 Inwood Drive, Houston, Texas

*HOUGH, JACK LUIN, Fountain Creek Survey, Soil Conservation Service, Colorado Springs, Colorado

HOWE, HENRY V., Department of Geology, Louisiana State University, University, Louisiana

*HOWELL, B. F., Department of Geology, Princeton University, Princeton, New Jersey

*HUGHES, ADEN W., 425 Lincoln Street, Bakersfield, California

HUGHES, DONALD D., 1718 El Rito Avenue, Glendale, California

ISRAELSKY, MERLE C., Union Producing Company, Box 2492, Houston, Texas

JABLONSKI, EUGENE, Socony-Vacuum Oil Company, Room 1137, 26 Broadway, New York, N. Y.

*JAMISON, CLAUDE T., Box 74, Terrell Wells, Texas

JANOVY, JOHN, Louisiana Land and Exploration Company, Houma, Louisiana

JOHNSON, F. W., Lago Petroleum Corporation, Apt. 172, Maracaibo, Venezuela, S. A.

JOHNSON, J. HARLAN, Colorado School of Mines, Golden, Colorado

*JOHNSON, WILLIAM R., Nebraska Geological Survey, Lincoln, Nebraska
*JONES, BRADFORD C., Box 201, Palos Verdes Estates, California
*JORDAN, LOUISE, Anzac Oil Corporation, Coleman, Texas
*JUNG, DOROTHY ANNE, Republic Production Company, Petroleum Building, Houston, Texas
KAUFMANN, GODFREY F., Standard Oil Company of Venezuela, Apt. 1329, Caracas, Venezuela, S. A.
KAY, G. MARSHALL, Department of Geology, Columbia University, New York, N. Y.
KEMP, AUGUSTA HASSLOCK, Seymour Public Schools, Box 626, Seymour, Texas
*KINDLE, E. M., 33 Woodlawn, Ottawa, Ontario, Canada
*KING, RALPH H., 2239 West Drive, Lawrence, Kansas
KING, ROBERT EVANS, Shell Oil Company, Inc., Midland, Texas
KLEINPELL, ROBERT M., 502 Boulevard Alhambra Apt., 30 Dewey Blvd., Manila, Philippine Islands
KNIGHT, J. BROOKES, Department of Geology, Princeton University, Princeton, New Jersey
KNIKER, HEDWIG T., 134 W. Agarita Avenue, San Antonio, Texas
KOCH-LAMBERT, RICHARD E., 30 Carel van Bylandtlaan, The Hague, Netherlands
KRUMBEIN, WILLIAM C., Department of Geology, University of Chicago, Chicago, Illinois
LAIMING, BORIS G., The Texas Company, 929 South Broadway, Los Angeles, California
LALICKER, CECIL G., Department of Geology, University of Oklahoma, Norman, Oklahoma
LEATHEROCK, CONSTANCE, 720 South Denver, Apt. D-5, Tulsa, Oklahoma
*LEE, A. THEODORE, 2716 W. 82nd Street, Inglewood, California
LEVORSEN, A. I., 221 Woodward Boulevard, Tulsa, Oklahoma
*LIEBUS, ADALBERT, Professor of Paleontology, Vinična 3, Prag, Czechoslovakia
LINK, THEODORE A., Geology Department, Imperial Oil Co., Ltd., Calgary, Alberta, Canada
*LIPSCOMB, VERNON F., Pure Oil Company, Box 2107, Fort Worth, Texas
*LOEBLICH, ALFRED R., 452 College Avenue, Norman, Oklahoma
LUGN, ALVIN L., Department of Geology, University of Nebraska, Lincoln, Nebraska
LYNCH, S. A., 3007-A Fruth Street, Austin, Texas
MACFAYDEN, W. A., Tenterden, Hope's Grove, Kent, England
MACNAUGHTON, LEWIS W., 611 Continental Building, Dallas, Texas
MALKIN, DORIS S., 2508 Stanmore Drive, Houston, Texas
MANGER, G. E., Mene Grande Oil Company, Apt. 234, Maracaibo, Venezuela, S. A.
MARTIN, JAMES L., Department of Conservation, Louisiana State University, University, Louisiana
*MARTIN, LOIS T., 772 Santa Ynez Avenue, Stanford University, California
MAY, ARTHUR R., 2615 22nd Street, Bakersfield, California
MAY, GEORGE N., Union Sulphur Company, Sulphur, Louisiana
MCCAMMON, JOHN HENRY, JR., Petrol Grubu, M. T. A., Ankara, Turkey
MILLER, A. K., Department of Geology, Iowa State University, Iowa City, Iowa
MILLS, LLOYD C., Box 2107, Fort Worth, Texas
*MINCHER, ALBERT RUSSELL, 221 Cherry Street, Lafayette, Louisiana
MINTON, J. W., Sun Oil Company, McAllen, Texas
MISER, HUGH D., U. S. Geological Survey, Washington, D. C.
MONSOUR, ELI T., 1769 Lake Shore Drive, Shreveport, Louisiana
MONTGOMERY, J. C., Harrison Oil Company, Box 2279, Houston, Texas
MOORE, Raymond C., Department of Geology, University of Kansas, Lawrence, Kansas
MOORE, WILLIAM B., Atlantic Oil and Refining Company, Esperson Building, Houston, Texas
MOREMAN, W. L., Geology Department, Magnolia Petroleum Company, Box 1828, Oklahoma City, Oklahoma
*MOREY, PHILIP S., Shell Oil Company, Inc., Shell Building, Houston, Texas
MORGAN, CHARLES GILL, United Geophysical Company, 177 North Hill Avenue, Pasadena, California

MORNHINVEG, A. R., United Gas System, Box 2492, Houston, Texas

MORRISON, T. E., Humble Oil and Refining Company, 1065 Humble Annex, Houston, Texas

MORROW, A. LYNDON, Magnolia Petroleum Company, 917 First National Building, Wichita, Kansas

MOSES, H. F., Carter Oil Company, Box 801, Tulsa, Oklahoma

MOSSMAN, R. W., Seismograph Service Corporation, 709 Kennedy Building, Tulsa, Oklahoma

MULLERRIED, FREDERICO K. G., 11a Cordoba 197, Mexico, D. F.

MURRAY, GROVER, School of Geology, Louisiana State University, University, Louisiana

*NADEAU, BETTY KELLETT, 2572 West Point Drive, Maplewood, Missouri

NATLAND, M. L., 4155 Chestnut Avenue, Long Beach, California

NEEDHAM, C. E., New Mexico School of Mines, Socorro, New Mexico

NEILL, W. B., Stanolind Oil and Gas Company, Box 3092, Houston, Texas

NEWELL, NORMAN D., Department of Geology, University of Wisconsin, Madison, Wisconsin

NICOL, DAVID, 4067 Mattison, Fort Worth, Texas

*NUTTALL, W. L. F., Bataafsche Petr. Mij., Carel van Bylandtlaan, The Hague, Netherlands

OLSSON, AXEL L., 48 Woodside Avenue, Gloversville, New York

OWENS, FRITH CRAVENS, Nueces Royalty Company, Drawer 30, Corpus Christi, Texas

*PALMER, DOROTHY, Neptuno 1060, Havana, Cuba

PALMER, KATHERINE V. W., 206 Oak Hill Road, Ithaca, New York

*PARKER, FRANCES, 46 Carlton, Brookline, Massachusetts

PATTON, LEROY T., 2415 19th Street, Lubbock, Texas

PAYNE, MAX, Richfield Oil Corporation, 312 Professional Building, Bakersfield, California

*PETTIJOHN, F. J., University of Chicago, Chicago, Illinois

PETTY, DABNEY E., Petty Geophysical Engineering Company, Drawer 1447, San Antonio, Texas

*PFANNKUCHE, MRS. H. C., Pure Oil Company, Fort Worth, Texas

*PIAZ, GIORGIO DAL, Direttore Istituto Geologico, via Giotto 20, Padova, Italy

†PLUMMER, F. B., Bureau of Economic Geology, University of Texas, Austin, Texas

PONTON, GERALD M., 39 Fullerwood Drive, St. Augustine, Florida

POOR, R. S., Birmingham-Southern College, Birmingham, Alabama

PORCH, EDWIN L., JR., Box 573, San Antonio, Texas

PYEATT, LLOYD M., Box 1346, Houston, Texas

REDFIELD, R. C., 819 Wendel, Houston, Texas

REED, EUGENE C., 1316 South 24th Street, Lincoln, Nebraska

REESIDE, JOHN B., JR., Box 177, Hyattsville, Maryland

REITER, WILHELM A., 923 Esperson Building, Houston, Texas

REVELLE, ROGER, Scripps Institution of Oceanography, La Jolla, California

RICHARDS, J. T., Gulf Oil Corporation, Box 1557, Oklahoma City, Oklahoma

RIES, HEINRICH, Department of Geology, Cornell University, Ithaca, New York

RIGGS, ROBERT J., Stanolind Oil and Gas Company, Box 591, Tulsa, Oklahoma

*RIVERO, FRANCES CHARLTON, "Casa Blanca," Los Chorros (Estado Mirando), Venezuela, S. A.

ROLSHAUSEN, F. W., Humble Oil and Refining Company, 1068 Humble Building, Houston, Texas

ROMANS, WILLIAM A., Box 168, Baton Rouge, Louisiana

ROPER, FRANK CHARLES, 527 Esperson Building, Houston, Texas

ROSS, J. D., Box 3404, Manila, Philippine Islands

RUSSELL, R. DANA, Department of Geology, Louisiana State University, University, Louisiana

*RUTSCH, R., Naturhistor. Museum, Basle, Switzerland

RYNIKER, CHARLES, Gulf Oil Corporation, Box 661, Tulsa, Oklahoma

SAMPLE, CHARLES HURST, Houston Oil Company, Petroleum Building, Houston, Texas

SANDIDGE, JOHN R., Magnolia Petroleum Company, 1704 Alamo National Building, San Antonio, Texas

SAAS, LOUIS CARL, Kuwait Oil Company, Kuwait, Persian Gulf

*SCHENCK, HUBERT G., Box 1528, Stanford University, California

†SCHUCHERT, CHARLES, Peabody Museum, Yale University, New Haven, Connecticut

SCHWEERS, RICHARD HENRY, 4705 Byers, Fort Worth, Texas

*SCOBEY, ELLIS H., Box 482, Mattoon, Illinois

SCOTT, GAYLE, Department of Geology, Texas Christian University, Fort Worth, Texas

SEAGER, O. A., Carter Oil Company, Box 1502, Billings, Montana

SEASHORE, P. T., Louisiana Land and Exploration Company, Houma, Louisiana

SELIG, A. L., Stanolind Oil and Gas Company, Box 3092, Houston, Texas

SELLARDS, E. H., Bureau of Economic Geology, University of Texas, Austin, Texas

SENN, ALFRED, British Union Oil Company, Box 177, Barbados, B. W. I.

SETZER, FRANCIS M., Stanolind Oil and Gas Company, Box 3092, Houston, Texas

SHAY, D. C., Box 941, Baton Rouge, Louisiana

SHOENFELT, C. E., Petroleum Information, Inc., Continental Oil Building, Denver, Colorado

SIDWELL, RAYMOND, Department of Geology, Texas Technological College, Lubbock, Texas

SIEGFUS, STANLEY S., Socony-Vacuum Oil Company, C. A., Apt. 246, Caracas, Venezuela, S. A.

SIMON, LOUIS J., Superior Oil Company, Geological Lab, Box 578, Shafter, California

SIMONSON, RUSSELL R., 534 D Street, Taft, California

*SIX, RAY L., Department of Geology, Oklahoma Agricultural and Mechanical College, Stillwater, Oklahoma

SMALL, WALT M., c/o Romano-Americana, Teleajen (Ploesti), Roumania

SMITH, FRED E., United Gas System, Box 2492, Houston, Texas

*SMITH, JAMES, 1721 Bushnell, South Pasadena, California

SMITH, RALPH E., 904 College Avenue, Norman, Oklahoma

SOHN, I. G., Schermerhorn Hall, Geological Department, Columbia University, New York, N. Y.

SPENCER, MARIA, Superior Oil Company, Box 510, Midland, Texas

SPIEKER, EDMUND M., Orton Hall, Ohio State University, Columbus, Ohio

*STADNICHENKO, TAISIA, Department of the Interior, U. S. Geological Survey, Washington, D. C.

STAINBROOK, MERRILL A., Department of Geology, Texas Technological College, Lubbock, Texas

STAUFFER, CLINTON R., Department of Geology, University of Minnesota, Minneapolis, Minnesota

STENZEL, H. B., Bureau of Economic Geology, University of Texas, Austin, Texas

STEPHENSON, LLOYD W., U. S. Geological Survey, Washington, D. C.

STEPHENSON, MORTON B., Stanolind Oil and Gas Company, Box 3092, Houston, Texas

*STEWART, DUNCAN, Carleton College, Worthfield, Minnesota

STILL, J. T., 3 Oak Court, Houston, Texas

STUCKEY, CHARLES W., JR., Stanolind Oil and Gas Company, Box 3092, Houston, Texas

STUDT, CHARLES W., Sagamore Oil and Gas Company, Independence, Kansas

*SUTTON, A. H., Department of Geology, University of Illinois, Urbana, Illinois

*SWARTZ, FRANK M., 722 North Atherton, State College, Pennsylvania

TAYLOR, DEWITT E., 2400 18th Street, Bakersfield, California

TAYLOR, RALPH E., Freeport Sulphur Company, Port Sulphur, Louisiana

TAYLOR, WILLIAM HARLAN, 315 N. W. 17th Street, Oklahoma City, Oklahoma

*THALMANN, HANS E., Regentesselaan 7, Palembang (Sumatra)

THOMAS, NORMAN L., Box 38, Bakersfield, California

*THOMPSON, MARCUS L., New Mexico School of Mines, Socorro, New Mexico

THOMPSON, S. A., Magnolia Petroleum Company, Box 900, Dallas, Texas

*THORP, E. M., Soil Conservation Service, Box 1558, Greenville, South Carolina

TIEJE, ARTHUR J., Cordova Hotel, 826 W. 8th Street, Los Angeles, California

*TOEPELMAN, WALTER C., University of Colorado, Boulder, Colorado

TOMLINSON, CHARLES W., 509 Simpson Building, Ardmore, Oklahoma

TRASK, PARKER D., U. S. Geological Survey, Washington, D. C.
TROWBRIDGE, A. C., 1182 East Court Street, Iowa City, Iowa
TSCHOPP, H. I., Shell Oil Company of Ecuador, Ltd., Apt. 340, Quito, Ecuador, S. A.
TULLIS, EDWARD L., Department of Geology, South Dakota School of Mines, Rapid City, South Dakota
TWENHOFEL, W. H., Department of Geology, University of Wisconsin, Madison, Wisconsin
UPP, JERRY E., Amerada Petroleum Corporation, Box, 2040, Tulsa, Oklahoma
UPSON, MARLIN E., Gulf Oil Corporation, Box 1290, Fort Worth, Texas
VAUGHAN, T. WAYLAND, 3333 P Street, Washington, D. C.
*WALDO, A. W., College of the Pacific, Stockton, California
WANLESS, HAROLD R., Department of Geology, University of Illinois, Urbana, Illinois
WARTHIN, ALDRED S., Department of Geology, Vassar College, Poughkeepsie, New York
WATERS, JAMES ALTON, Sun Oil Company, Box 2880, Dallas, Texas
*WATSON, ELIZABETH, Box 542, Stanford University, California
WEAVER, CHARLES E., Department of Geology, University of Washington, Seattle, Washington
WEDEL, ARTHUR, Box 1141, Jackson, Mississippi
WEEKS, H. J., Sun Oil Company, 1608 Walnut, Philadelphia, Pennsylvania
WEEKS, WARREN B., Phillips Petroleum Company, Box 1729, Shreveport, Louisiana
*WELCH, ROBERT N., Louisiana Geological Survey, University, Louisiana
WELLER, J. MARVIN, State Geological Survey, Urbana, Illinois
WELLMAN, DEAN C., Box 271, Tulsa, Oklahoma
*WENTWORTH, CHESTER K., Honolulu Board of Water Supply, Honolulu, Hawaii
WESTHEIMER, JEROME MAX, 815 3d Avenue Southwest, Ardmore, Oklahoma
WESTMORELAND, FRANK S., 2311 Dunstan Road, Houston, Texas
WEYMOUTH, A. ALLEN, Box 295, Gisborne, New Zealand
WHIPPLE, G. LESLIE, No. 2 Bath Island Road, Indian Oil Concessions, Ltd., Karachi, India
WHITE, MAYNARD P., Gulf Oil Corporation, Box 30, Ardmore, Oklahoma
*WHITE, R. T., 1923 Bank Street, Bakersfield, California
WHITNEY, F. L., 2715 Splitrock, Austin, Texas
*WICKENDEN, ROBERT T. D., Geological Survey of Canada, Ottawa, Ontario, Canada
*WILLIAMS, JAMES STEELE, U. S. Geological Survey, Washington, D. C.
WILLIAMS, JOHN R., 801 West Nevada Street, Urbana, Illinois
WINKLER, HANS, 104 West 32nd Street, Austin, Texas
WINTON, W. M., Department of Geology, Texas Christian University, Fort Worth, Texas
WISSLER, STANLEY G., Union Oil Company of California, Box 511, Compton, California
WOODFORD, ALFRED O., 443 West 10th Street, Claremont, California
WRATHER, W. E., 4300 Overhill Drive, Dallas, Texas

* Associate Members.
† Honorary Members.

## ERRATUM

The following correction should be made in the paper by Mr. J. B. Garrett on "Some Middle Tertiary smaller Foraminifera from subsurface beds of Jefferson County, Texas," which appeared in the Journal of Paleontology, volume 13, number 6, p. 575: The sentence which reads "All of the species herein described were taken from a core from Stanolind Oil and Gas company no. B-2 Pipkin, Big Hill Prospect, Jefferson County, Texas" should read, "All of the species herein described were taken from cores from Stanolind Oil and Gas company no. B-2 Pipkin, Big Hill Prospect, Jefferson County, Texas."

**Verlag von Gebrüder Borntraeger in Berlin W 35 Deutschland**

**Fortschritte der Paläontologie.** prepared under direction of O. H. Schindewolf, Berlin, with aid of numerous specialists. Vol. 1—Review of the years 1935-1936, contains 384 pp., 2 figs. Price, RM 29.60.

*Fortschritte der Paläontologie* is intended to be a biennial publication indicating significant advances in paleozoology and paleobotany by means of critical summaries and discussion of the most important works issued in successive two-year periods. The first volume, now available, covers literature of 1935 and 1936, and provides a comprehensive view of the present status of paleontological research.

**Paläontologie,** Entwicklungs- und Vererbungslehre (Paleontology, Evolutionism and Genetics) by O. H. Schindewolf; contains 108 pages, 34 text figures; published 1936. Price, RM 5.20.

This volume develops from paleontological observations and theoretical considerations a new orientation of studies on evolution. Critical inquiry on questions of evolutionary factors and a refutation of Lamarckian theories leads to accommodation of previously divergent views on evolution and heredity.

**Detailed descriptions and prospectuses free**

# BACK VOLUMES AT HALF PRICE

Members and associate members of the Society of Economic Paleontologists and Mineralogists and of the Paleontological Society and subscribers of the

## JOURNAL OF PALEONTOLOGY

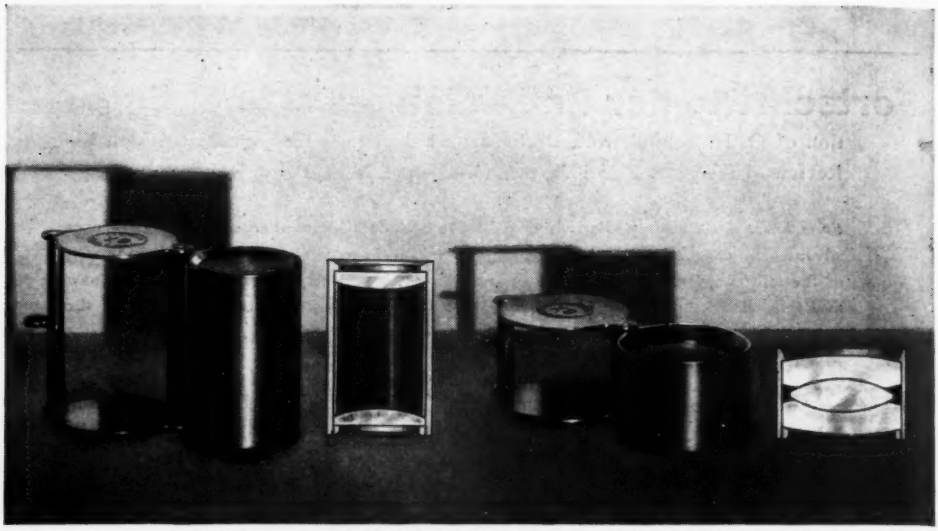
will be privileged for a limited time to purchase complete Volumes 2 (1928) to 11 (1937) at the very special price of Three Dollars ($3.00) per volume. This offer represents a 50 per cent discount from regular prices and gives opportunity that should not be overlooked. Furthermore, only part of the supply of back volumes will be sold at this price. The stock of Volume 1 is exhausted, but any others can be purchased. Place order promptly if you wish to secure discount because this offer will be withdrawn as soon as allotment of copies is exhausted.

Members and associate members of the Society of Economic Paleontologists and Mineralogists and subscribers of the

## JOURNAL OF SEDIMENTARY PETROLOGY

may purchase, for a limited time, complete Volumes 1 (1931) to 7 (1937), at half price, One Dollar and a Half ($1.50) per volume.

SOCIETY OF ECONOMIC PALEONTOLOGISTS AND MINERALOGISTS
Box 979, Tulsa, Oklahoma



*Left, Spencer Doublet Magnifier; right, Spencer Triple Aplanat. The drawings show the lens system.*

# *Finest optical quality distinguishes*

## these Spencer Magnifiers

Two types of hand magnifiers—each available in a range of six different magnifications—are produced by Spencer to meet the multitude of uses which are served by these handy instruments.

Spencer Triple Aplanats are corrected both spherically and chromatically and are noted for their large, flat field, brilliance and long working distance.

Spencer Doublets, although not as well corrected as Triple Aplanats, give excellent central definition.

Both are characterized by the same high optical standards which distinguish Spencer microscope objectives.

HAND MAGNIFIERS in folding case (6X, 9X, 12X, 15X, 18X, 24X magnifications)

Triple Aplanats .....$7.50
Doublets ..... 3.25

} Available in plain black enamelled mounts for use in dissecting microscopes at $1.00 less.

***Write Dept. C56 for further details***

# Spencer Lens Company

MICROSCOPES
MICROTOMES
PHOTOMICROGRAPHIC
EQUIPMENT

SPENCER
BUFFALO
U.S.A.

REFRACTOMETERS
COLORIMETERS
SPECTROMETERS
PROJECTORS

# OFFICERS OF THE SOCIETIES

## SOCIETY OF ECONOMIC PALEONTOLOGISTS AND MINERALOGISTS

*For the year ending April, 1940*

*President*, GAYLE SCOTT, Fort Worth, Texas.

*Past-President*, E. H. SELLARDS, Austin, Texas.

*Past-President*, S. G. WISSLER, Compton, Calif.

*Vice-President*, HERSCHEL L. DRIVER, Glendale, Calif.

*Secretary-Treasurer*, HENRYK B. STENZEL, Austin, Texas.

## THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS

*For the year ending April, 1940*

*President*, HENRY A. LEY, San Antonio, Texas.

*Past-President*, DONALD C. BARTON, Houston, Texas.

*Vice-President*, L. MURRAY NEUMANN, Tulsa, Okla.

*Secretary-Treasurer*, ED. W. OWEN, San Antonio, Texas.

*Editor*, W. A. VER WIEBE, Wichita, Kansas.

*Society Headquarters*, 608 Wright Bldg., Tulsa, Okla.

## PALEONTOLOGICAL SOCIETY

*For the year ending December, 1940*

*President*, C. O. DUNBAR, New Haven, Conn.

*Past-President*, R. W. CHANEY, Berkeley, Calif.

*Vice-President*, P. S. WARREN, Edmonton, Alberta.

*Secretary*, H. E. VOKES, New York, N.Y.

*Treasurer*, ROBERT R. SHROCK, Cambridge, Mass.

*Editor*, C. WYTHE COOKE, Washington, D.C.

## GEOLOGICAL SOCIETY OF AMERICA

*For the year ending December, 1940*

*President*, ELIOT BLACKWELDER, Stanford University, Calif.

*Past-President*, T. WAYLAND VAUGHAN, Washington, D.C.

*Vice-President*, Douglas Johnson, New York, N.Y.

*Vice-President*, E. L. BRUCE, Kingston, Ont.

*Vice-President*, RALPH W. CHANEY, Berkeley, Calif.

*Vice-President*, M. N. SHORT, Tucson, Ariz.

*Secretary*, C. P. BERKEY, New York, N.Y.

*Treasurer*, E. B. MATHEWS, Baltimore, Md.

*Society Headquarters*, 419 West 117th St., New York, N.Y.

# SPECIAL SALE

*Revised List*

## A.A.P.G. BULLETIN BACK VOLUMES

"The Industry's Authority in Petroleum Geology"

The demand for back volumes of the A.A.P.G. Bulletin has exhausted the supply of some issues and a few are unavailable even at premium prices. In several years, however, large editions were printed and there are on hand at headquarters certain paper- and cloth-bound volumes which may now be purchased at specially attractive prices. Most of these copies are practically as good as new; a few have slightly soiled covers. The text and illustrations are intact.

***This is an exceptional opportunity for members, non-members, companies, and educational institutions alike to fill the gaps in their libraries or to obtain duplicate copies. The prices quoted are the same to all, payable in advance, postage free.***

This is a sale of Bulletin *volumes* (calendar-year basis: January-December); not of single monthly numbers. One volume, or as many as desired, may be purchased. The Association reserves the right to discontinue this sale at any time.

| *Paper-Covered Volumes* | *Present Special Sale Price* | *Regular Published Price* |
|---|---|---|
| Vol. V (1921)—No. 1 missing. Pp. 113-724 | 2.00 | 11.50 |
| Vol. VI (1922)—No. 1 missing. Pp. 65-600 | 2.00 | 10.00 |
| Vol. VII (1923)—Nos. 2, 3 and 6 missing. Pp. 1-93; 331-602. | 3.00 | 12.00 |
| Vol. VIII (1924)—No. 2 missing. Pp. 1-134; 269-860 | 3.00 | 10.00 |
| Vol. IX (1925)—Nos. 1, 2, 3 missing. Pp. 359-1319. Salt-dome papers | 5.00 | 15.00 |
| Vol. X (1926)—No. 2 missing. Pp. 1-103; 205-1339. Salt-dome papers | 5.00 | 15.00 |
| Vol. XIII (1929)—1612 pp., complete | 5.00 | 15.00 |
| Vol. XIV (1930)—1610 pp., complete | 5.00 | 15.00 |
| Vol. XV (1931)—1476 pp., complete | 5.00 | 15.00 |
| Vol. XVI (1932)—No. 6 missing. Pp. 1-532; 629-1378 | 5.00 | 15.00 |
| *Clothbound Volumes, Gold Stamped* | | |
| Members and associates who paid dues in 1927-1931 are entitled to clothbound volumes (only 1 copy per year per member) at $5; second copies at $6. | | |
| Vol. XI (1927)—1376 pp., complete. Includes several foreign papers, and 16 papers in *Struc. Typ. Amer. Oil Fields*, Vol. I | 6.00 | 17.00 |
| Vol. XII (1928)—1204 pp., complete. Includes Symposium on Pennsylvanian-Permian Stratigraphy of Southwestern United States | 6.00 | 17.00 |
| Vol. XIII (1929)—1612 pp., complete | 6.00 | 17.00 |
| Vol. XIV (1930)—1610 pp., complete. Includes Review of Geophysical Prospecting in 1929 | 6.00 | 17.00 |
| Vol. XV (1931)—1476 pp., complete. Includes Stratigraphy of Plains of Southern Alberta and Symposium on Geophysics | 6.00 | 17.00 |

**23 VOLUMES OF THE BULLETIN HAVE BEEN PUBLISHED (1917-1939) IS YOUR SET COMPLETE?**

**PRICES OF BULLETINS NOT INCLUDED IN SPECIAL SALE WILL BE FOUND IN COMPLETE PRICE LIST SENT ON REQUEST**

**THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS**

**BOX 979, TULSA, OKLAHOMA, U.S.A.**